Comparison of two types of proximal femoral nails in the treatment of intertrochanteric femur fractures

Gökçer Uzer, M.D.,¹ Nuh Mehmet Elmadağ, M.D.,¹ Fatih Yıldız, M.D.,¹ Kerem Bilsel, M.D.,¹ Tunay Erden, M.D.,¹ Hüseyin Toprak, M.D.²

¹Department of Orthopedics and Traumatology, Bezmialem Vakif University Faculty of Medicine, Istanbul
²Department of Radiology, Bezmialem Vakif University Faculty of Medicine, Istanbul

ABSTRACT

BACKGROUND: Hip nailing is frequently used to treat unstable intertrochanteric femoral fractures (ITF) in elderly patients. In this retrospective study, we compared the functional and radiological results, and the complications, of patients treated using proximal femoral nails (PFN) with an integrated, interlocking, compression lag screw, or two separate lag screws, which allow linear compression at the fracture site.

METHODS: A total of one hundred and eighteen patients were operated on for AO/OTA 31-A2 ITF between May 2010 and April 2012, and eighty-two of these patients, for whom sufficient follow-up data and documentation were available, were included into the study. PFNs with interlocking, integrated lag screws (Group I) were used in forty-four patients, and PFNs with two separate lag screws (Group II) in thirty-eight. Outcome parameters were the extent of varus collapse and leg length discrepancy on radiographs, and the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and Harris hip scores (HHS) as functional results.

RESULTS: Mean follow-up duration was 20 months (range, 12–36 months); fractures healed in all patients. Mean varus collapse values were 2.03±5.68° and 5.21±5.27° (p=0.01), Harris hip scores 73.2±11.65 and 74.72±11.15 (p=0.54), and WOMAC scores 70.78±11.41 and 71.78±11.19 (p=0.69) in Groups I and II, respectively. No difference was detected between the groups in terms of outcome parameters or complication rate.

CONCLUSION: In the treatment of ITF, PFNs with an integrated, interlocking, compression lag screw, or two separate lag screws did not differ in terms of functional and radiological results or complication rate.

Keywords: Compression; hip nailing; intertrochanteric femur fractures; proximal femoral nail.

INTRODUCTION

Intertrochanteric femoral fractures (ITF) are one of the most frequent lower extremity fractures that usually occur following minor trauma in the elderly, caused by osteoporosis.¹² Hip nailing, which is associated with short surgery time, stable fixation, and early postoperative mobilization, is the preferred osteosynthetic method used to treat elderly patients with ITF.¹³–¹²

Materials and Methods

A total of one hundred and eighteen consecutive patients diagnosed with ITF (AO 31-A2) was admitted to the Emergency Department of our hospital between May 2010 and April 2012, and were treated by six surgeons. This study was performed in accordance with the Declaration of Helsinki;
data were collected from charts and the outcomes of the most recent postoperative follow-up visits.

Inclusion and Exclusion Criteria

Patients ≥60 years of age at the time of surgery were included into the study. Patients who could not self-ambulate or who had severe neurological problems that affected ambulation were excluded. Trauma mechanism was another criterion; patients who developed ITF after a simple ground-level fall and who underwent at least 12 months of follow-up were included. Thirty-six patients were excluded; 17 were lost to follow-up, 16 died, and 3 underwent hemiarthroplasty because of metastatic lesions. Thus, eighty-two patients (48 female and 34 male; mean age, 76.6 years; range, 61–114 years) were included. All patients were osteoporotic, with mean Singh's index values of 3.8±1.04 and 4.1±1.19 in Groups I and II, respectively (p=0.207). Mean time to surgery after fracture was three days (range, 1–13 days).

Types and Designs of Proximal Femoral Nails

PFNs with an interlocking, integrated lag screw (Group I) were used in forty-four patients (mean age, 76.1 years; range, 67–89 years). PFNs with two separate lag screws (Group II) were used in thirty-eight patients (mean age, 78.5 years; range, 61–114 years). No difference in mean age was observed between the groups (p=0.325). Intertan PFNs (Smith & Nephew, Memphis, TN, USA), manufactured from a titanium alloy, with a trapezoidal cross-section, with a 4° valgus offset, a 17 mm proximal-end diameter, a clothespin distal tip, and diameters of 10 and 11.5 mm, were used in Group I. The lag and compression screws for Group I were an integrated, interlocking screw construct that included two screws of diameters of 11 and 7 mm (total, 15.5 mm), and the nail was fixed via dynamic or static distal locking. The compression screw affords intraoperative interfragmentary compression at the fracture site. Profin PFNs (TST SAN, Istanbul, Turkey), cannulated straight tubes, are manufactured from titanium alloy, and have a proximal curvature of 6° and a distal slotted design, and were used in Group II. Two 8.5-mm lag screws of neck-shaft angle 135° were inserted. Interfragmentary fracture compression was also possible intraoperatively using this design. The proximal part of the nail was 16 mm in diameter, and the distal diameters of the nails were 10, 11, and 12 mm. The nails also had two distal holes that allowed for dynamic or static fixation using 4.5-mm locking screws.

Surgical Technique

All patients underwent surgery on a traction table in supine position. Closed reduction of the fracture was achieved under fluoroscopic control and minimally invasive techniques were used during nailing. Both nail types were inserted through the tip of the greater trochanter. Intraoperative interfragmentary compression was achieved in Group I after inserting an 11 mm lag screw using a 7 mm interlocking, integrated compression screw. However, interfragmentary compression was achieved in Group II using two separate lag screws inserted through the nail. The distal hole was statically locked in both groups.

Follow-Up

All patients were allowed to bear as much weight as they could tolerate on postoperative day 1. The patients were examined at weeks 3 and 6, month 3, and after the first year; antero-posterior (AP) and lateral radiographs were taken.

Outcome Parameters

Maintenance of reduction, varus collapse, and union were the radiological outcomes evaluated by a radiologist. Fracture reduction was evaluated using the criteria of Baumgaertner et al., as modified by Fognagnolo et al.[13-16] The collodiaphyseal angle was measured at the initial postoperative visit on follow-up AP radiographs. A collodiaphyseal angle that decreased to <125° during follow-up was considered to indicate significant varus collapse. Tip-apex distances (TAD) were measured as described by Baumgaertner, on the initial postoperative X-rays of the patients who exhibited varus collapse (Fig. 1). As two separate lag screws were used in Group II, TAD was measured from the tip of the proximal screw.[16] Fracture union was defined radiologically as the development of callus, and, clinically, by a reduction in groin pain. WOMAC and HHS were evaluated as functional outcomes.[17]

Statistical Analysis

Kolmogorov–Simirnov test was used to check for normality, Student’s t-test to compare data between groups, and the chi-squared test to compare complication rates between the groups. P-values <0.05 were considered significant.

RESULTS

Seven patients (13%) in Group I and nine (19%) in Group...
II died during follow up. The remaining forty-four patients in Group I and thirty-eight in Group II attained their final follow-ups. Mean follow-up duration was 20 months (range, 12–36 months).

According to the criteria of Baumgaertner et al., as modified by Fogagnolo et al., the quality of reduction was good in eighteen patients, acceptable in nineteen, and poor in seven of Group I; and good in sixteen, acceptable in fourteen, and poor in eight of Group II.

Mean initial postoperative and final follow-up neck-shaft angles were 130.41±5.30° and 128.38±7.37° in Group I (p=0.02) and 131.76±4.83° and 126.54±6.12° in Group II (p<0.001). Mean initial postoperative (p=0.235) and final follow-up neck-shaft angles (p=0.229) were similar between the groups. Significant varus collapse was observed in seven patients in each group. Mean extent of significant varus collapse was 2.03±5.68° in Group I and 5.21±5.27° in Group II (p=0.01; Table 1). Mean TAD values on the initial postoperative X-rays of patients with varus collapse were 34.10±9.85 and 32.07±11.37 in Groups I and II, respectively (p=0.74).

Mean HHS and WOMAC scores were 73.2±11.65 and 70.78±11.41 in Group I and 74.72±11.15 and 71.78±11.19 in Group II, respectively. The differences in mean HHS (p=0.549) and WOMAC scores (p=0.690) were not significant between the groups (Fig. 2).

Complications

Seven complications occurred in seven patients in Group I because of significant varus collapse: lateral migration of lag screws in four, lag screw cut-out in two (the screws were replaced with shorter screws), and chondral destruction because of a malpositioned lag screw in one (who later underwent total hip arthroplasty) (Fig. 3a-c). Nine patients in Group II developed nine complications: two superficial infections treated via appropriate medications, two iatrogenic femoral shaft fractures revised using long recon nails, and seven with significant varus collapse. Superior malpositioning of the lag screws in one patient who had varus collapse was revised with use of a long recon nail. Hypertrophic non-union in one patient was revised using a 95° AO plate and an autograft.

The Z-effect was evident in four patients after varus collapse; two were asymptomatic after removing the screws; and the other two did not undergo any intervention. A lag screw in one patient was revised due to a reverse Z-effect (Fig. 4a-d). The complication rates in Groups I (16%) and II (23%) did not differ (p=0.37) (Tables 2 and 3).

DISCUSSION

Stable fixation and early mobilization decrease both morbidity and mortality rates and improve functional results when ITF is to be treated in elderly patients and those with osteoporosis.[3,4] Most complications associated with PFN use while treating ITF are varus collapse of the proximal femur, cut-out, shortening of the femur, non-union, secondary fracture of the femur or trochanter major, thigh pain, screw fracture, heterotopic ossification, and a Z-effect or reverse Z-effect of nails with two lag screws.[4] In this study, two different PFNs

<table>
<thead>
<tr>
<th>Table 1. Patient demographics and results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>HHS</td>
</tr>
<tr>
<td>WOMAC</td>
</tr>
<tr>
<td>The difference in collodiaphyseal angle</td>
</tr>
<tr>
<td>Singh index</td>
</tr>
<tr>
<td>Complication rate</td>
</tr>
</tbody>
</table>

HHS: Harris Hip Score; WOMAC: Western Ontario and McMaster Universities Arthritis Index.
were compared, which are used in the treatment of unstable ITFs, and it was found that two different PFN designs yielded comparable results. Although the collodiaphyseal angle decreased significantly in both groups during follow-up, the extent of varus collapse was significantly higher in Group II than in Group I. Despite the statistically significant extent of varus collapse in both groups, neither the functional results nor the union and complication rates differed between the groups.

In our study, the significant varus collapse was most probably caused by an increased TAD, evident on the initial postoperative X-rays (34.10±9.85 and 32.07±11.37 in groups I and II, respectively). Lag screw design, which allows for intraoperative linear compression of the fracture, may explain why fewer cases of varus collapse were evident in group I than group II. However, the varus collapse rate did not directly correlate with union rate. Ruecker et al. have evaluated the outcomes of patients fixed with Intertan PFNs to treat ITF and reported varus collapse in two of 48 patients, although both had TAD values <5 mm on AP radiographs.[18] In the study of Zhang et al., InterTAN and proximal femoral nail antirotation (PFNA) have been compared. The results have shown that the extent of shortening at the femoral neck is greater in the InterTAN than in the PFNA group, whereas all of the union rate, walking ability, Harris hip score, and hip range of motion, have been similar between the two groups.[19]
The results of a biomechanical study comparing PFNs with one or two lag screws have indicated that PFNs with two lag screws might be a better option in patients with good bone quality, but have been associated with a higher risk of cut-out in elderly patients with osteoporosis.[20] In our study, the cut-out rate as a result of varus collapse was 4.5% in Group I, consistent with studies by Ruecker et al. (4.1%) and Megas et al. (4.6%).[21] Zhang et al. have reported a cut-out rate of 1–3% in a PFNA group, whereas no patient has developed cut-out in the Intertan group.[19] In the biomechanical study of Huang et al., femoral strength, stability, and bearing capacity have been higher in the InterTAN group than in the PFNA group.[22]

Lin has reported that the use of PFNs with two lag screws is effective to treat AO OTA A1-A2-A3 ITF.[17] In the study by Erturer et al., union has been achieved in all thirty-two patients treated using Profin PFNs, although two patients have undergone revision surgeries because of poor fracture reduction.[23]

Gardenbroek et al. have retrospectively reviewed one hundred and fifty-seven patients with unstable ITF; the patients have been treated using PFNA or PFNs. The results were similar when the position of the implant in the femoral head was compared between nail types, but the risk of complications and the need for secondary surgery were higher in the PFN group than in the PFNA group.[8] In our study, the risks of secondary surgery and screw cut-out did not differ between the groups.

The Z-effect (lateral migration of an inferior lag screw), varus collapse, perforation of the femoral head by the superior lag screw, the “reverse Z-effect,” (lateral migration of a superior lag screw), and medial migration of the inferior lag screw, typically occur because the proximal fragment tilts as a result of insufficient medial cortical support.[24,25] Werner-Tutschku et al. first defined the Z-effect and reverse Z-effect in five of 70 patients, and the cut-out rate was 8.6%. They recommended fracture fixation at a neck-shaft angle >125° to decrease the risks of the Z-effect, reverse Z-effect, and screw cut-out of the femoral head.[26] Papasimos et al. have reported the Z effect in four of 40 patients.[3] The reverse Z effect has been seen in five of 35 patients in the series of Uzun et al.[4] and in two of 55 patients in the study by Boldin et al.[4,27] In a study by Herrera et al., including two hundred and fifty patients treated for pertrochanteric femoral fractures using the Gamma Nail and PFNs, the rates of cut-out and fracture around nail tips have been statistically significantly higher in the Gamma Nail group than in the PFN group, but the rates of varus collapse and lag screw migration have been significantly higher in the PFN group than in the Gamma Nail group.[28] In our study, the neck-shaft angle was <125° in seven patients of Group I, and lateral migration was detected in four; they did not undergo re operations, but the proximal lag screws were replaced with shorter screws in two patients because of screw cut-out. Nine Group II patients had collodiaphyseal angles <125°, and varus collapse and the Z-effect were observed in four; the lag screws were removed in two patients. The lag screw of one patient in Group II was replaced with a shorter screw because a reverse Z-effect was evident.

Table 2. Patient complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertrophic nonunion</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Secondary fracture</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Z effect</td>
<td>–</td>
<td>4</td>
</tr>
<tr>
<td>Reverse Z effect</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Superficial infection</td>
<td>–</td>
<td>2</td>
</tr>
<tr>
<td>Lateral migration</td>
<td>4</td>
<td>–</td>
</tr>
<tr>
<td>Cut-out</td>
<td>2</td>
<td>–</td>
</tr>
<tr>
<td>Chondral destruction</td>
<td>1</td>
<td>–</td>
</tr>
</tbody>
</table>

Table 3. Comparison and review of the complication rates of our study and those in the literature.

<table>
<thead>
<tr>
<th>Patient (n=)</th>
<th>Complication rate (%)</th>
<th>Cut-out (%)</th>
<th>Lateral migration*/Z-Effect**</th>
<th>Death rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herrera et al.[25]</td>
<td>125 (PFN)</td>
<td>4.8</td>
<td>0.8</td>
<td>3.2*</td>
</tr>
<tr>
<td></td>
<td>125 (Gamma Nail)</td>
<td>7.2</td>
<td>4</td>
<td>5.6*</td>
</tr>
<tr>
<td>Park et al.[28]</td>
<td>46</td>
<td>10.8</td>
<td>-</td>
<td>4.3**</td>
</tr>
<tr>
<td>Soucanye de Landevoisin et al.[29]</td>
<td>102</td>
<td>16.7</td>
<td>2.9</td>
<td>15.7*</td>
</tr>
<tr>
<td>Werner-Tutschku et al.[23]</td>
<td>70</td>
<td>10</td>
<td>8.5</td>
<td>7.1*</td>
</tr>
<tr>
<td>Simmermacher et al.[7]</td>
<td>315</td>
<td>14.6</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Current study</td>
<td>44 (InterTAN)</td>
<td>16</td>
<td>4.5</td>
<td>9.1*</td>
</tr>
<tr>
<td></td>
<td>38 (Profin)</td>
<td>23</td>
<td>-</td>
<td>13**</td>
</tr>
</tbody>
</table>

*: Lateral migration of the lag screws; **: Lateral migration of the inferior lag screw and cut-out of the superior lag screw due to varus collapse of the femoral head.
A secondary fracture distal to the nail is a significant complication of hip nailing. Banan has reported this complication in two of 46 patients and Fogagnolo et al. in one of 47. Similarly, two of our Group I patients exhibited this complication; one was revised immediately, and the other three days later, using long femoral antegrade nails. This complication did not occur in any Group II patients.

In a study by Rappold et al., nail fractures around the proximal screw holes have occurred in three patients. In our study, we achieved union using a 95° AO plate after lag screw fractures developed in one patient.

Limitations
We investigated the effect of lag screw design on outcome. The Barthel index and the Parker and Palmer mobility score are other appropriate measures of functional outcomes but we did not use them in the current study. The retrospective study design and the small number of patients constitute other limitations.

Conclusion
Hip nailing is a safe and minimally invasive method for the treatment of unstable intertrochanteric femoral fractures. Our functional and radiological results, and complication rates, did not differ significantly when a PFN with an integrated, interlocking, lag screw construct, or a PFN with two separate lag screws, were used.

Conflict of interest: None declared.

REFERENCES
25. Pires RE, Santana EO Jr, Santos LE, Giordano V, Balbachovsky D, Dos Reis FB. Failure of fixation of trochanteric femur fractures: Clinical recom-
26. Uzer et al. Comparison of two types of proximal femoral hails in the treatment of intertrochanteric femor fractures
Uzer et al. Comparison of two types of proximal femoral nails in the treatment of intertrochanteric femur fractures

İntertrokanterik femur kırıklarının tedavisinde iki farklı proksimal femur civisinin karşılaştırılması

Dr. Gökçer Uzer,¹ Dr. Nuh Mehmet Elmadağ,¹ Dr. Fatih Yıldız,¹ Dr. Kerem Bilsel,¹ Dr. Tunay Erden,¹ Dr. Hüseyin Toprak²

¹Bezmialem Üniversitesi Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dalı, İstanbul
²Bezmialem Üniversitesi Tıp Fakültesi, Radyoloji Anabilim Dalı, İstanbul

AMAÇ: Kalça çivileme (PFN) yaşlı hastalardaki instabil intertrokanterik femur kırıklarının (ITF) tedavisinde sık kullanılmaktadır. Bu geriye dönük çalışmada, kırık sahasında kompresyona izin veren birbirine entegre, birbirine kilitlenebilir kompresyon lag vidası kiti ya da iki ayrı lag vidası kullanlan PFN ile tedavi edilmiş olan hastaların fonksiyonel, radyolojik sonuçları ve komplikasyonları karşılaştırıldı.

GEREÇ VE YÖNTEM: Mayıs 2010 ve Nisan 2012 tarihleri arasında, AO/OTA 31–A2 ITF kırığı için ameliyat edilmiş olan 118 hastadan takipleri ve kayıtları yeterli olan 82’si incelendi. Kompresyon yapabilen, birbirine kilitlenebilir, entegre lag vidası kiti olan PFN (Grup I) 44 hastada, iki ayrı lag vidası olan PFN ise (Grup II) 38 hastada kullanıldı. Sonuç parametreleri radyolojik olarak varusta çökme ve bacak boyu eşitsizliği, fonksiyonel olarak da Batı Ontario ve McMaster Üniversitesi artrit indeksi (WOMAC) ve Harris kalça skorları (HHS) idi.

BULGULAR: Ortalama takip süresi olan 20 (12–36) ayda tüm kırıklar iyileşti. Grup I ve Grup II’de sırasıyla, ortalama varus çökmesi 2.03° ve 5.21° (p=0,01), ortalama WOMAC skorları ise 70,78 ve 71,78 (p=0,69) olarak bulundu. Sonuç parametreleri ve komplikasyon oranları bakımından gruplar arasında anlamlı bir fark görülmüyordu (p>0,05).

TARTIŞMA: İntertrokanterik femur kırıklarının tedavisinde, birbirine entegre ve birbirine kilitlenebilir kompresyon lag vidası veya iki ayrı lag vidası kullanılan PFN’ler arasında fonksiyonel, radyolojik sonuçlar ve komplikasyon oranları açısından fark bulunmamaktadır.

Anahtar sözcükler: İntertrokanterik femur kırığı, kompresyon, proksimal femur çivisi.