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ORIGINAL STUDY

Hemiarthroplasty with cementless intramedullary stem versus proximal femoral nail in the treatment of unstable intertrochanteric fractures in elderly patients

Seyran KILINÇ, Özhan PAZARCI

From the Department of Orthopaedics and Traumatology, Faculty of Medicine, Sivas Cumhuriyet University, Sivas, Turkey

Several methods are used in the treatment of unstable intertrochanteric hip fractures in elderly patients with high mortality and morbidity. The aim of this study was to compare and present the clinical and radiological results of two alternative methods : cementless distal intramedullary stems and proximal femoral nail (PFN).

One hundred and seventeen patients who were over 70 years of age and operated on in our clinic for unstable intertrochanteric fractures between January 2014 and January 2018 were included in this study. In addition to the sociodemographics, patients' Singh index, type of fracture, time to surgery, duration of surgery, blood need, blood loss, length of hospital stay, concomitant diseases, complications, ASA scores, time to mortality and mobilization statuses were recorded. The data collected was evaluated using the SPSS v.23 software.

The duration of surgery, intraoperative bleeding amount, postoperative drainage and blood requirement amounts, and the use of fluoroscopy in HA were significantly higher than PFN ($p<0.001$). There was no significant difference between the groups in terms of one-year mortality rate. Similarly, no significant difference was detected between the groups in terms of the latest mobilization status of the patients.

Patients who underwent HA were found to be associated with high bleeding amount and long duration of surgery. The groups exhibited similar results in terms of one-year mortality rate and functional results. Neither type of the implants is superior to the other, therefore both can be effectively used in the treatment of unstable hip fractures in the elderly. On the other hand, the femoral stem design in the study is a alternative treatment method for uIT fractures but the surgery is technically challenging and should be undertaken by an experienced arthroplasty surgeon.

Keywords : Advanced age ; cementless intramedullary stem ; elderly ; mortality ; proximal femoral nail ; unstable intertrochanteric fracture.

INTRODUCTION

Hip fractures tend to be the leading cause of morbidity and mortality in the aging population, which continues to increase over the years *(1,2)*. An unsuccessful surgery can result in the disability of the patient and increased treatment costs *(3)*. Treatment of these fractures include several different methods. The surgeon should evaluate the patient properly and plan the optimal treatment with appropriate implant selection *(4)*.

The treatment of osteoporotic hip fractures in the elderly, especially those with unstable inter-

■ Seyran Kilinç,
■ Özhan Pazarci
Department of Orthopaedics and Traumatology, Faculty of Medicine, Sivas Cumhuriyet University, Sivas, Turkey.
Correspondence : Seyran Kilinç, Cumhuriyet Universitesi Tıp Fakültesi, Ortopedi ve Travmatoloji Anabilim Dali, 58140, Sivas, Turkey. Phone : (+90-531) 793 0068.
Email : seyrankilinc@hotmail.com

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trochanteric (uIT) fractures, is challenging. Even if an adequate reduction and a stable internal fixation are performed, a revision surgery secondary to fixation failure may be required. This may cause increased morbidity in patients *(5,6)*. Hemiarthroplasty (HA) that allows early mobilization is an implant option for those patients *(5,7,8)*. Hemiarthroplasty has been investigated in various studies depending on whether it is performed with or without cement, and whether a calcar-replacement was performed *(6,7,9-11)*.

The literature holds a limited number of studies on patients that underwent HA with cementless distal intramedullary femoral stems for unstable femoral intertrochanteric fractures. In a few studies, the preference of this implant has been shown to allow for an easy surgical technique and provide good functional results *(12)*. However, no study including the comparison of HA with this femoral stem to proximal femoral nail (PFN) was found in the literature.

The aim of our present study was to compare and present the clinical and radiological results of the elderly patients who underwent HA with cementless distal intramedullary stems and those who underwent PFN fixation of unstable intertrochanteric hip fractures.

PATIENTS AND METHODS

Following the approval of the local ethics committee, 152 patients who presented to our clinic for uIT fractures between January 2014 and January 2018 were evaluated. Patients who were under 70 years of age, had high-energy traumas, had pathological fractures, had been treated with an implant other than the implants used in our study, and those whose data files were not available were excluded from the study. Of the remaining 117 patients (71 HA, 46 PFN), all had osteoporotic unstable femoral intertrochanteric fractures that occurred after simple in-home falls. Sociodemographic information was obtained from the patients' files retrospectively. Patients' age, gender, Singh index, type of fracture, time to surgery, implant selection, duration of surgery, blood need, blood loss during and after surgery, length of hospital stay, concomitant diseases, complications, and the American Association of Anesthesiologists (ASA) scores were recorded.

The cause of death of the patients were recorded. Patient survivals were evaluated under four episodes : perioperative period, first three months, first year and still alive. Concomitant diseases were noted and ASA scoring was performed. Patients who were operated on within and after the first 48 hours were compared and evaluated. Mobilization statuses of the surviving patients were assessed through phone calls and with the findings from final examination.

Hemiarthroplasty was performed in the lateral decubitus position and with a posterior approach using T2 hip prosthesis (TIPSAN® AS, Izmir, Turkey) without cement. The external rotator muscles were suspended, the capsule was opened, the head was exposed, and the femoral canal was prepared with reamers similar to the technique in intramedullary nailing. The femoral stem was placed to fit the canal diameter and femoral bowing. For the press-fit detection of the stem, the femoral stem was internally-externally rotated and the fixation was checked. The height of the femoral stem was adjusted by placing the trochanteric module at the appropriate height onto the stem. Press-fit fixation of the stem was checked with the internal-external rotation of the femoral stem. The height of the femoral stem was adjusted by placing the trochanteric module at the appropriate height onto the stem. The hip joint was reduced by placing a head of appropriate diameter in the femoral stem. Stabilization was achieved by fixing the trochanter major using cable-plate, control cable or non-absorbable suture, according to the size of the part. Intraoperative fluoroscopy check was performed. Hip movements were checked at 90 degrees of flexion, 45 degrees of abduction-adduction and 45 degrees of internal-external rotation. A drain was installed and the skin folds were closed duly (Figure 1).

Fixation with proximal femoral nail (INTERTAN Nail System ; Smith+Nephew, Inc., Andover, MA, USA) was performed while the patient was placed in the lateral decubitus position without using the traction table. An incision was made over 3-5 cm

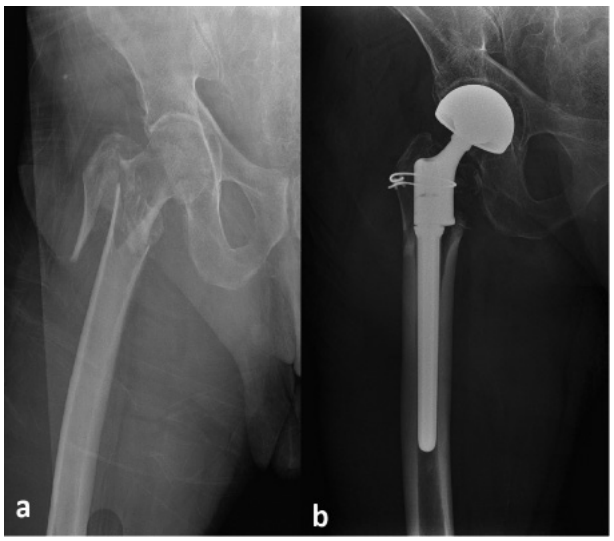

Figure 1. — Anteroposterior radiographs of our 76-year-old male patient **(a)** before and **(b)** after hemiarthroplasty with distal intramedullary fixation. The femoral stem has been fixed in the medullary canal press-fit.

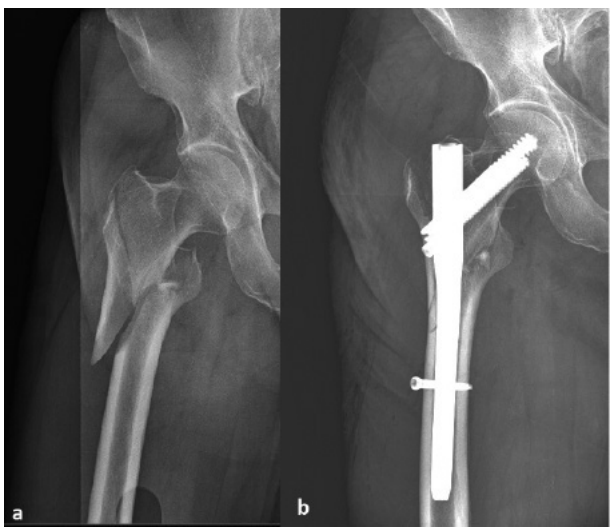

Figure 2. — Anteroposterior radiographs of our 73-year-old male patient **(a)** before and **(b)** after proximal femoral nailing.

proximal of the greater trochanter. The fracture was reduced under fluoroscopic guidance. After insertion of the guide wire, the canal was drilled and the nail was placed in it. The lag screw was placed for compression, in the appropriate position under fluoroscopy. In patients where a reduction couldn't be achieved, the fracture fragment was reduced with a mini incision from the lateral and the nailing process was performed. Drains were placed in the trochanter area and the skin folds were properly closed (Figure 2).

All patients were administered prophylaxis of venous thromboembolism with low-molecular-weight heparin.

Statistical analyses were completed using the SPSS v.23.0. The chi-square test was used for comparisons of categorical variables. Normal distribution of the continuous variables was tested with the Kolmogorov-Smirnov test. The mean differences between groups were analyzed using the Kruskal-Wallis and Mann-Whitney U tests. Survival analysis was performed with the Kaplan-Meier method. Statistical significance level was set at $p<0.05$.

RESULTS

The average age of the 76 HA patients (44 females, 27 males) was 82.17 years (range : 70 to 98 years), whereas the average age of the 46 PFN patients (25 females, 21 males) was 80.20 years (range : 70 to 91 years). There was no significant difference between the groups in terms of age ($p=0.413$). Patients' Singh index, type of fracture, duration of surgery, number of fluoroscopies performed during surgery, amount of intraoperative bleeding, amount of hemorrhage from the postoperative drain, total amount of blood loss, postoperative blood requirement, ASA scores, current additional diseases, durations of surgery, laboratory values, length of hospital stay, and follow-up time data are shown in Table 1.

The duration of surgery, the amount of intraoperative bleeding, the amount of blood in the hemovac drain and the amount of blood requirement were significantly higher in HA patients than PFN patients ($p<0.001$). The number of fluoroscopies performed during the surgery was higher in PFN patients ($p<0.001$).

Mobilization status of the 66 patients who were still alive at the time of the study was examined. In the HA group, 35 patients were mobilized without support and eight patients could walk with support before the fracture. In the PFN group, 21 patients were mobilized without support and two patients could walk with support. Postoperatively, in the

Table 1. — Clinical characteristics of the patients according to the type of implant

		HA	PFN	p value
Gender, n	Female	44 (62.0%)	25 (54.3%)	0.413
	Male	27 (38.0%)	21 (45.7%)	
Age (years) ±SD (range)		82.17±6.29	80.20±5.43	0.104
Singh index ±SD (range)		2.66±0.79 (1-4)	2.28±0.91 (1-4)	0.316
Fracture type based on AO classification	A22	19 (26.8%)	7 (15.2%)	0.073
	A23	27 (38.0%)	18 (39.1%)	
	A31	0 (0.0%)	4 (8.7%)	
	A32	12 (16.9%)	6 (13.0%)	
	A33	13 (18.3%)	11 (23.9%)	
	Total	71 (100.0%)	46 (100.0%)	
Lab results	Hb	11.78±1.45	12.35±1.78	0.059
	Plt	241253.52±96163.95	228369.57±64955.49	0.765
ASA score	1	1 (1.4%)	1 (2.2%)	0.321
	2	39 (54.9%)	26 (56.5%)	
	3	31 (43.7%)	17 (37.0%)	
	4	0 (0.0%)	2 (4.3%)	
	Total	71 (100.0%)	46 (100.0%)	
Duration of surgery ±SD (range) minutes		66.42±13.48 (50-120)	58.33±17.52 (40-110)	**<0.001**
Number of intraoperative fluoroscopies ±SD (range)		2.85±1.09 (2-8)	16.93±4.48 (10-30)	**<0.001**
Intraoperative blood loss ±SD (range) ml		401.41±114.94 (180-710)	206.52±111.84 (50-600)	**<0.001**
Postoperative drainage ±SD (range) ml		205.63±60.59 (120-360)	89.57±76.30 (0-360)	**<0.001**
Total blood loss ±SD (range) ml		607±159.57 (320-965)	296±184.66 (50-960)	**<0.001**
Blood need (ES) ±SD (range) units		2.18±1.73 (0-8)	1.61±1.64 (0-6)	**0.049**
Time to surgery	48 h <	22 (31.0%)	19 (41.3%)	0.263
	48 h >	49 (69.0%)	27 (58.7%)	
Length of hospital stay ±SD (range) days		10.41±4.10 (5-24)	11.93±9.45 (4-66)	0.695
Follow-up period ±SD (range) months		20.97±17.47 (1-65)	25.41±19.44 (1-60)	0.307
Number of preoperative comorbidities	Alzheimer	5 (7.0%)	2 (4.4%)	0.487
	Hypertension	32 (45.1%)	30 (65.2%)	
	DM	12 (16.9%)	10 (21.7%)	
	Cardiovascular disease	9 (12.7%)	15 (32.6%)	
	Respiratory disease	2 (2.8%)	3 (6.5%)	
	Heart failure	8 (11.3%)	4 (8.7%)	
	Nonvascular neurological disorders	2 (2.8%)	5 (10.9%)	

ASA : American Society of Anesthesiologists, DM : diabetes mellitus, HA : hemiarthroplasty, Hb : haemoglobin, PFN : proximal femoral nail, Plt: platelet count, SD : standard deviation. Significant p values are written in bold.

HA group, 18 patients needed no walking aids, 22 needed aids (walker, crutches, etc.) and three were immobile. In the PFN group, nine patients could walk with no walking aids, 12 could walk with aids and two were immobile. There was no significant difference in terms of mobilization between the groups (p^{preop}=0.285 and p^{postop}=0.957 ; Table 2).

There was no significant difference between the groups in terms of one-year mortality rate (HA : 19 deceased [26.8%], PFN : 11 deceased [23.9%]) (p=0.730). Kaplan-Meier analysis revealed no significant difference between the groups (p>0.05) (Figure 3).

Table 2. — Latest mobilization statuses of the surviving patients.

	Preoperative		Postoperative		p^{preop}	p^{postop}
	HA	PFN	HA	PFN		
No need for walking aids	35 (81.4%)	21 (91.3%)	18 (41.9%)	9 (39.1%)		
Need for walking aids (unaccompanied)	8 (18.6%)	2 (8.7%)	22 (51.2%)	12 (52.2%)	0.285	0.957
Immobile	0 (0%)	0 (0%)	3 (7.0%)	2 (8.7%)		
Total	43 (100%)	23 (100%)	43 (100%)	23 (100%)		

p^{preop}: comparison of the HA and PFN groups according to their preoperative mobilization statuses. p^{postop}: comparison of the HA and PFN groups according to their postoperative mobilization statuses.

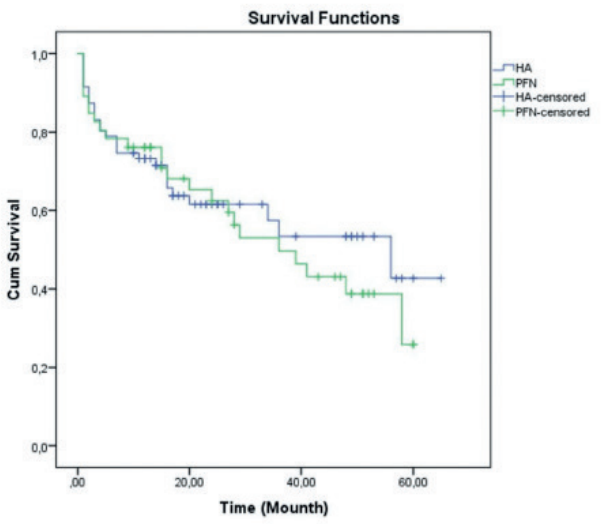

Figure 3. — Time to mortality in HA and PFN patients (Kaplan-Meier survival analysis).

Fractures of the greater trochanter in HA was sutured with cable in 37 patients and non-absorbable sutures in 28 patients, while trochanteric plating was performed in six patients. In follow-up, cable was broken in two patients. In spite of this, a union was observed in the trocantric fragment. In five patients, union failure was observed. However, there was no functional problem. Therefore, no additional treatment was performed for these patients. No fixation was performed for posteromedial corner fracture. None of the patients showed any signs of femoral stem collapse or loosening on the HA follow-up radiographs. Union was observed in the PFN group at about the third month and all patients had full union latest by the sixth month. Heterotopic ossification developed in one patient in the HA group. Due to the cut-out complication of the lag screw in two patients in the PFN group, revision surgery was performed at the third and sixth months. Superficial infection was observed in three patients in the HA group and it was treated with debridement + antibiotherapy. Deep infection occurred in one patient. The patient was offered a two-stage revision, however, she refused treatment. No infection was seen in the PFN group. A femoral fracture occurred in the HA group intraoperatively. The fracture was fixed with cable and no problem was observed during the follow-up period.

There was no significant difference between the groups in terms of gender, age, Singh index, type of fracture, ASA score, length of hospital stay, follow-up time and additional diseases (Table 1).

DISCUSSION

In our study, clinical results of the patients with uIT fractures who underwent HA with cementless distal intramedullary stems and those who underwent PFN fixation were compared and presented. Studies comparing these two techniques are limited in the literature. In addition, our study stands out with the fact that no intervention for posteromedial fixation was performed on any patient that underwent HA.

Treatment of uIT fractures in elderly patients is still controversial and the number of comparative studies in the literature are limited *(5,11,13,14)*. The main purpose of treatment in uIT fractures, especially

in the elderly patients, should be to mobilize the patient as soon as possible and return the patient to the condition before the fracture *(15)*. Although some authors have advocated osteosynthesis since internal fixation is a more biological method, some studies have reported that implant failure and restriction of immobilization will increase the complication rate in elderly patients *(11,16-20)*.

Hemiarthroplasty is a frequently encountered method in the literature with different implant options when the approaches to these fractures are considered. Cementless distal intramedullary stem designs used in these studies have been presented as a reliable alternative *(9,12,21)*.

The femoral stem used in our study consists of two parts. The distal part of the stem has grooves and is hydroxyapatite-coated, and is applied press-fit according to the lumen diameter. The grooves prevents the rotation of the stem. After the distal part is placed to ensure the length of the extremity, the trochanteric module, which is the proximal part, is placed by aligning it with respect to the greater trochanter. Thanks to the stem that shows distal intramedullary fixation, no extra fixation was required for the posteromedial corner fractures. We didn't observe any evidence of collapsing or loosening of the prosthesis during the follow-up period for the patients that underwent HA.

The main problem for surgeons is the inability for early load-bearing after internal fixation in elderly patients with uIT fractures, in addition to long-term bed rest which increases mortality and morbidity. Studies have shown that HA will allow for early mobilization in advanced age patients and decrease the complications associated with immobilization *(22)*. In a comparative study of cemented HA and PFN, it was emphasized that although HA allows for early mobilization, the difficulty of the surgical technique had impact on mortality and morbidity, and caused loosening of the prosthesis in the long term and worse functional results *(23)*. In another comparative study of cemented HA and PFN, although similar results were obtained in terms of 6-month mortality rates, the authors stated that HA patients had significantly worse morbidity outcomes, compared to PFN patients *(24)*. Similar results regarding the 6-month mortality and overall complication rates were reported in a comparison between intramedullary nailing and cemented-cementless HA in another multi-center study *(25)*. In our study, while the HA patients could bear full weight using a walker on the second postoperative day, the PFN patients could bear full weight after three months following complete union. Considering the impact of the limited immobilization on quarterly and annual mortality, we could not find a statistically significant difference (Figure 3).

Fixation of the trochanteric bone fragments are recommended for the stabilization of the femoral stem in HA. Also, it is crucial for future function and hip stability. In our study, although there were problems on the graph of seven patients, no functional problems were observed. There are various trochanteric fixation technics described in the literature. Fixation of the greater trochanter is important to maintain abductor lever arm and improve hip function after surgery *(26,27)*. On the other hand, repairing the posteromedial corner is of importance as it prevents stem collapse when using stems with intertrochanteric fixation *(7,9)*. This situation both prolongs surgery time and causes more blood loss. Since the femoral stem we used in our study had a distal intramedullary-fixing design, stabilization was achieved by fixing the stem press-fit in the medullary canal. Posteromedial corner was not fixed in any patient. When the surgical times in the two groups were compared, the HA group had significantly higher results. This finding was similar to those from other comparative studies in the literature *(11,24)*. In addition, the amount of blood loss during the operation, and the blood and total blood loss from the Hemovac drain were also significantly higher in the HA group. The closed and limited open reduction techniques in the PFN group explains the low amount of blood loss. On the other hand, the number of intraoperative fluoroscopic images in the PFN group was significantly higher than that of the HA group.

Hemiarthroplasty applications provide good early clinical results *(24,25)*. However, in their comparative study, Kim et al. reported that the three-year mortality rate was significantly higher in the HA group than the PFN group, and that arthroplasty had no functional advantage after two years *(11)*. In

our study, we concluded that the walking capacities of the patients before fracture and after the follow-up periods were not different between the groups and declined in a similar manner. We believe that the loss of mobilization in all groups was effective in the progress of the patients' systemic diseases.

The reoperation rates vary in uIT fracture treatment *(13,25)*. We performed revision surgeries in two patients as they encountered cut-outs, the most common complication seen in PFN patients. However, no other complications were observed in this group. In the HA group, deep infection developed in one patient, infection in three, heterotopic ossification in one, and intraoperative fracture in one. Although there were no mechanical complications in the HA patients, the high infection rate causes serious postoperative concerns. We believe that the limited surgical opening, short surgery time and low amount of bleeding decrease the incidence of infection in PFN patients.

Some authors advocate cemented HA to ensure adequate stabilization in elderly patients. However, the fat embolization that may develop during cementing in cemented HA patients causes serious mortality *(28,29)*. In a comparative study, six patients from the cement application group were reported to have died during surgery. However, the authors observed no difference in the one-year mortality rate *(10)*. The femoral stem used in our study provides sufficient stabilization without the need for cementation, thanks to its distal intramedullary fixation. Thus, it can be considered that the stem provides an advantage since it reduces the intraoperative cementation time and the complication rate. We did not experience any intraoperative patient loss in both groups, however, our study has shown that the surgery time of PFN patients was significantly less than that of HA. Agaist the current literature periprostatic fracture very low in our series *(30)*. Acording to the authors, these results depend on the femoral stem design and placement of the stem according to the intramedullary nailing principle. It has been emphasized in the literature that stem design affects the rates of periprosthetic fracture *(31)*. However, it should not be forgotten that this treatment method requires experience.

The retrospective design was a limitation of our study. In addition, the age group of our patients and the presence of additional diseases have limited the patient follow-up times and made it difficult to evaluate the isolated functional results.

In conclusion, the amount of bleeding, the duration of surgery and the risk of complications were found to be significantly low in advanced age uIT fracture patients that underwent PFN. The groups exhibited similar results in terms of one-year mortality rate and functional results. Considering that limited immobilization does not cause serious mortality, we believe that biological fixation is a good choice for this group of patients. On the other hand, the femoral stem design in the study is a alternative treatment method for uIT fractures but the surgery is technically challenging and should be undertaken by an experienced arthroplasty surgeon.

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