ORIGINAL ARTICLE

Examining implant superiority in the treatment of simple pertrochanteric fractures of the proximal femur in elderly patients

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ABSTRACT

BACKGROUND: The aim of this study was to compare the clinical and radiological results of the proximal femoral nail antirotation (PFNA) with those of the dynamic hip screw (DHS) and percutaneous compression plate (PCCP) in the treatment of simple pertrochanteric fractures.

METHODS: A total of 203 patients were included in the study. PFNA fixations were performed in 73 patients (PFNA group), DHS in 68 patients (DHS group), and PCCP in 62 patients (PCCP group). The main outcome measurements were perioperative properties, the Harris hip score, changes in the neck–shaft angle, and loss of the abductor muscle strength. Data were compared between the groups.

RESULTS: The mean estimated total blood loss and the number of patients receiving the blood transfusion rate in the PFNA group were statistically significantly lower. The mean operation and fluoroscopy times in the PCCP group were statistically significantly higher. The mean loss of the abductor muscle strength and changes in the neck–shaft angle in the PFNA group were statistically significantly higher. The mean Harris hip scores were similar.

CONCLUSION: Our findings demonstrated that although PFNA was superior with regard to the perioperative data, DHS and PCCP were superior in maintaining the reduction and the abductor muscle strenght. All three implants were similar and had satisfactory functional outcomes.

Keywords: Fixation devices; fracture fixation; hip fractures; osteosynthesis.

INTRODUCTION

Fractures of the proximal femur trochanteric region are common and are associated with increased mortality and morbidity, especially in the elderly population.[1–3] According to the Orthopedic Trauma Association classification system, simple pertrochanteric fractures are classified as AO/OTA 31A1.[4] These fractures are characterized by intact lateral walls. Their incidence, generally occurring after a simple fall and being associated with bone fragility, increases with age.[5]

The AO/OTA 31A1 fractures treating options include extramedullary and intramedullary fixation methods. The ideal implant is still the subject of discussion. Proximal femoral nail antirotation (PFNA) allows weight bearing on the affected limb and early mobilization and provides angular and rotational stability.[6] Dynamic hip screw (DHS) is the most common implant used for the fixation of simple pertrochanteric fractures.[7] In the literature,[8] functional and radiographic outcomes were similar between the PFNA and DHS. The percutaneous compression plate (PCCP) is an extramedullary fixation device that retains the fracture hematoma, minimizes soft tissue damage, and avoids excessive periosteal stripping.[9]

Although meta-analyses and reviews in the literature do exist,[6,10] a comparative clinical study examining the fixation of

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simple pertrochanteric fractures with PFNA, DHS, and PCCP is, to the best of our knowledge, yet to be published. We aimed to compare the clinical and radiological results of PFNA with those of DHS and PCCP for simple pertrochanteric fractures.

MATERIALS AND METHODS

This is a retrospective clinical study conducted following the approval of the ethical committee of our hospital.

We identified 246 patients aged 65–80 years diagnosed with a simple pertrochanteric fracture and who underwent fixation using PFNA (Tasarimmed, Istanbul, Turkey), DHS (Synthes Inc, West Chester, PA, USA), or PCCP (Orthofix SRL, Verona, Italy) between January 2011 and December 2016.

Our exclusion criteria were as follows: age 65–80 years; AO/OTA 31A1.1, 31A2, and 31A3 fractures; bilateral hip fracture; pathologic fractures; another fracture in the extremities or spine; open fractures; a history of lower-limb fracture or deformity; previous ipsilateral lower-limb surgery; contralateral hip fracture within the last year; cognitive impairment; and severe concomitant medical condition (Grades IV and V American Society of Anesthesiologists [ASA] score).[11] Additionally, 12 patients were lost to follow-up. A final total of 203 patients were included in the study. Seventy-three patients were treated with PFNA (Group PFNA), 68 patients with DHS (Group DHS), and 62 patients with PCCP (Group PCCP).

Data for this study were collected from patient records, a digital data bank, which included information on patients who were operated, and outpatient clinic notes. First, we analyzed mortality, orthopedic complications, and reoperation rates between the groups. Sixty-three patients because of mortality and a total of 15 patients because of orthopedic complications or reoperation requirements were excluded from the second analysis. A total of 125 patients were analyzed with respect to the pre- and perioperative patient characteristics and postoperative data. Forty-five patients were in the PFNA, 42 in the DHS, and 38 in the PCCP group.

Pre- and perioperative patient characteristics were collected following consent; these included age, gender, body mass index (BMI; kg/m²), the affected side, fracture etiology, AO/OTA classification of fractures,[4] Charlson comorbidity index (CCI),[12] ASA grade of the operative risk,[11] preoperative hemoglobin (g/dL) and hematocrit (mm/h) values, an estimated total blood loss (ml), patients receiving blood transfusion, preoperative time (days), operation duration (minutes), fluoroscopy duration (seconds), quality of reduction, and the length of hospital stay (days).

Postoperative data of the patients included the following: bone healing time (weeks), evaluated during the whole follow-up period, and clinical and radiological evaluation criteria evaluated only on the final follow-up. The latter included the Harris hip score (HHS),[13] loss of abductor muscle strength (AMS) (%), and change in the neck-shaft angle (NSA) (degrees).

All patients were classified using preoperative anteroposterior and lateral radiographic views as AO/OTA 31A1.2 or 31A1.3 according to the Orthopedic Trauma Association classification system (Fig. 1). The estimated total blood loss (ml) was calculated from the total volume of intraoperative aspiration fluids, drains, and blood on the gauze pad. The blood transfusion criterion was a hemoglobin level <9 g/dL. Anteroposterior and lateral radiographic views of the affected hip were evaluated 1–7 days after the operation and at each

Figure 1. Preoperative anteroposterior radiographic view of a patient with a 31A1.2 fracture according to the Orthopedic Trauma Association classification system.

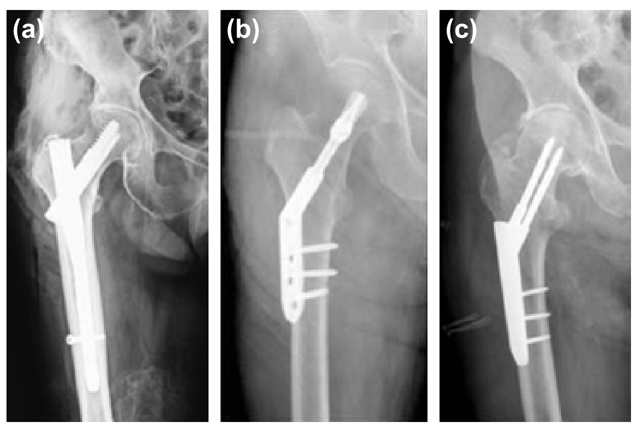

Figure 2. Early postoperative anteroposterior radiographic views of patients who had **(a)** PFNA, **(b)** DHS, and **(c)** PCCP.

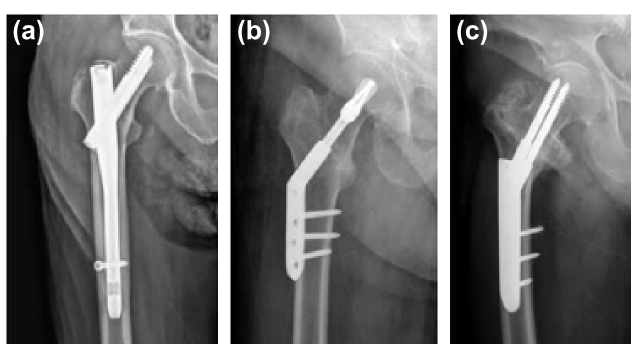

Figure 3. Final follow-up anteroposterior radiographic views of patients who had **(a)** PFNA, **(b)** DHS, and **(c)** PCCP.

follow-up visit in all patients (Fig. 2). Patients in both groups were followed up in the 6th week, 3rd month, 6th month, 9th month, and 1st year postoperatively. We also classified the quality of reduction as follows: poor (>10 degrees of varus, valgus, anteversion, or retroversion), acceptable (5–10 degrees), or anatomic (≤5 degrees).[14]

Evaluations of function and mobilization were assessed using HHS,[13] scaled from 1 to 100 points. Bilateral anteroposterior and lateral radiographs of the hip were conducted on the final follow-up (Fig. 3). The changes in NSA were calculated from differences observed between the affected and non-effected sides using anteroposterior radiographic views. Additionally, we measured the bilateral AMS of all patiens using a handheld dynamometer (Baseline Digital Smedley Spring Hand Dynamometer, Park City, UT, USA). The loss of AMS was calculated from differences observed between affected and non-effected sides. All variables were compared between the groups.

Surgical Procedure and Postoperative Management

Patients were admitted to the Emergency Department of our hospital after sustaining injury and were transferred to our department following stabilization of their systemic condition. Surgical treatment was performed as soon as possible. All procedures were performed under spinal or general anesthesia.

For fixation, patients were positioned supine on the radiolucent operation table, and closed reduction was performed with manual traction under C-arm fluoroscopic monitoring. Povidone–iodine or chlorhexidine was used for the sterile preparation of the injured limb prior to performing the procedure. A minimally invasive approach was used, whenever possible. Implant components were applied according to techniques recommended by the manufacturer. A postoperative fracture reduction and implant positioning were assessed by fluoroscopy.

A single dose of first-generation cephalosporin (sefazolin sodium) (1 g) prophylaxis was administered prior to surgery to all patients; four additional cephalosporin doses were administered postoperatively. In addition, low-molecular-weight heparin was administered from the hospitalization day 1 for 4 weeks after the operation as deep venous thrombosis prophylaxis. Active and passive exercises of the ankle and hip joints, as well as quadriceps strengthening, were initiated under the guidance of the surgeon. All patients were mobilized using a walking frame within 3 days. Three days after the procedure, the patients with PFNA started the partial weight-bearing movement (i.e., 15% of thebody weight), gradually transitioning to full weight-bearing movement 6 to 8 weeks after the procedure, depending on the fracture healing. Patients with DHS and PCCP started the partial weight-bearing movement (again, 15% of body weight) after callus was identified using X-ray fluoroscopy (i.e., 3 weeks after the procedure), gradually transitioning to the full weight-bearing movement, depending on the fracture healing speed.

Statistical Analysis

The SPSS 20.0 for Windows 7 (IBM, Inc., Armonk, NY, USA) was used for statistical analysis. Descriptive statistics were given as the number and percentage for categorical variables and the mean and standard deviation for numerical variables. The numerical variables in the more than two groups were compared using the one-way analysis of variance when provided the normal distribution condition in the groups. The

Table 1. Comparison of the mortality, orthopedic complications, and reoperation rates

Variable	PFNA group (n=73)		DHS group (n=68)		PCCP group (n=62)		p*
	n	%	n	%	n	%	
Mortality in 1 year	16	21.9	12	17.6	13	21	0.806
Total mortality	23	31.5	22	32.4	18	29	0.914
Periprosthetic fracture	0	0.0	1	1.5	0	0	0.637
Limb length discrepancy (>25 mm)	0	0.0	6	8.8	4	6.5	0.021#
Malunion	4	5.5	2	2.9	1	1.6	0.566
Nonunion	2	2.7	1	1.5	1	1.6	1.000
Heterotopic ossification	2	2.7	3	4.4	2	3.2	0.895
Screw cut-out	5	6.8	5	7.4	2	3.2	0.563
Implant failure	0	0.0	1	1.5	0	0	0.637
Osteolysis with well-fixed implants	1	1.4	0	0	0	0	1.000
Wound infection	2	2.7	1	1.5	1	1.6	1.000
Reoperation	5	6.8	4	5.9	6	9.7	0.694

*Chi-squared analysis. #Subgroup analysis: PFNA vs. DHS, p=0.011; PFNA vs. PCCP, p=0.042; DHS vs. PCCP, p=0.747.
PFNA: Proximal femoral nail antirotation; DHS: Dynamic hip screw; PCCP: Percutaneous compression plate.

numerical variables in more than two groups were compared using the Kruskal–Wallis test when no normal distribution condition was provided. The subgroup analysis was performed using the Mann–Whitney U test in nonparametric test. The ratios in the groups were compared using the chi-squared analysis. The subgroup analysis was interpreted using the Bonferroni correction in nonparametric and chi-square tests. For all tests, the statistical significance was defined as an alpha level of $p<0.05$.

RESULTS

There were no statistically significant differences with respect to mortality, orthopedic complications, and reoperation rates, except for the limb length discrepancy (LLD) between the groups (Table 1). The LLD rate in the PFNA group was statistically significantly lower than that of DHS (p=0.011) and PCCP (p=0.042) groups.

In the second analysis, the mean age of the 125 patients was 72±5.3 years, the mean BMI was 30.8±4.8, and 62 (49.6%) patients were male. The mean estimated total blood loss (ml) and the number of patients receiving the blood transfusion rates in the PFNA group were statistically significantly lower than in the DHS and PCCP groups. The mean procedure duration (minutes) and fluoroscopy (seconds) times in the PCCP group were statistically significantly higher than those in the PFNA and DHS groups. Pre- and perioperative characteristics of patients are presented in Tables 2 and 3.

The mean HHS in the PCCP group was statistically significantly higher than the one in the DHS group. The mean AMS loss (%)

Table 2. Patient data

Variable	PFNA group (n=45)	DHS group (n=42)	PCCP group (n=38)	p*
Age (years), mean±SD	73.9±4.6	70.6±5.4	71.3±5.5	0.010
Sex (male/female), n	20/25	25/17	17/21	0.288
Body mass index (kg/m²), mean±SD	30.2±4.2	29.6±4.8	32.7±4.9	0.008**
Side (right/left), n	23/22	16/26	23/15	0.130
Fracture etiology (SF/FFH/MVA), n	41/1/3	40/0/2	35/1/2	0.946
AO/OTA classification (31A1.2/31A1.3), n	15/30	12/30	22/16	0.016
Charlson comorbidity index, mean±SD	3.27±1.30	2.81±1.49	3.03±1.26	0.348
ASA grade, n (%)				0.648
I	7 (15.6)	11 (26.2)	8 (21.1)	
II	18 (40)	11 (26.2)	13 (34.2)	
III	20 (44.4)	20 (47.6)	17 (44.7)	
Preoperative hemoglobin (g/dL), mean±SD	11.6±2.1	10.6±2.0	12.6±1.9	<0.001
Preoperative hematocrit, mean±SD	34.8±6.3	32.0±6.0	37.8±5.9	0.001
Estimated total blood loss (mL), mean±SD	167.3±27.6	344.0±61.7	353.9±55.9	<0.001
Patients receiving the blood transfusion, n (%)	5 (11.1)	14 (33.3)	11 (28.9)	0.037
Preoperative time (days), mean±SD	3.6±1.3	4.0±1.6	3.9±1.7	0.455
Operation time (minutes), mean±SD	26.1±5.6	25.6±5.5	35.3±9.6	<0.001
Fluoroscopy time (seconds), mean±SD	57.8±16.7	55.8±15.0	67.6±19.3	0.012
Length of hospital stay (days), mean±SD	5.6±1.6	5.9±1.8	5.6±1.6	0.667
Quality of reduction, n (%)				0.405
Good	24 (53.3)	22 (52.4)	25 (65.8)	
Acceptable	21 (46.7)	20 (47.6)	13 (34.2)	
Poor	–	–	–	
Bone healing time (weeks), mean±SD	15.4±2.3	14.7±2.9	15.5±3.0	0.459
Harris hip score, mean±SD	75.4±8.7	70.8±5.9	77.8±8.6	0.003
Loss of AMS (%), mean±SD	21.8±5.8	2.6±3.7	3.1±4.4	<0.001
Change in the neck–shaft angle (degrees), mean±SD	2.49±1.04	1.43±0.59	1,26±0.69	<0.001
Follow-up period (years), mean±SD	4.13±1.63	3.95±1.48	4.26±1.62	0.713

*Kruskal–Wallis test; **One-way analysis of variance. SF: Simple falling; FFH: Falling from a high; MVA: Motor vehicle accident; ASA: American Society of Anesthesiologists; AMS: Abductor muscle strength; PFNA: Proximal femoral nail antirotation; DHS: Dynamic hip screw; PCCP: Percutaneous compression plate; SD: Standard deviation.

Table 3. Subgroup analysis of variables with statistically significant difference

	PFNA vs. DHS	PFNA vs. PCCP	DHS vs. PCCP
	p*	p*	p*
Age (years)	0.004	0.037	0.415
Body mass index	0.811	0.041	0.009
AO/OTA classification**	0.631	0.025	0.008
Preoperative hemoglobin (g/dL)	0.030	0.040	<0.001
Preoperative hematocrit	0.055	0.037	<0.001
Estimated total blood loss (ml)	<0.001	<0.001	0.585
Patients receiving the blood transfusion*	0.012	0.040	0.673
Operation time (minutes)	0.713	<0.001	<0.001
Fluoroscopy time (seconds)	0.598	0.022	0.004
Harris hip score	0.059	0.122	0.001
Loss of abductor muscle strength (%)	<0.001	<0.001	0.605
Change of neck-shaft angle (degrees)	<0.001	<0.001	0.299

*Mann–Whitney U test; **Chi-squared analysis. PFNA: Proximal femoral nail antirotation; DHS: Dynamic hip screw; PCCP: Percutaneous compression plate.

and NSA change (degrees) in the PFNA group were statistically significantly higher than those of DHS and PCCP groups. Postoperative data of patients are presented in Tables 2 and 3.

DISCUSSION

Hip fractures which frequency increases with an advanced age have become a public health issue. Adult hip fractures should be treated surgically to prevent morbidity and mortality, improve patient mobilization, decrease the of length rehabilitation, improve the quality of life, and reduce costs and complications.

Although numerous investigators have recommended treating the AO/OTA 31A1.2 and 31A1.3 fractures with an intramedullary nail, DHS, or PCCP,[15,16] to the best of our knowledge, no clinical studies have compared these three implants for these stable fractures. We therefore evaluated the pre-, peri-, and postoperative properties of patients who underwent PFNA or DHS or PCCP. Especially, we aimed to compare these implants with respect to the loss of AMS.

We found that the mortality for the 1-year rates was 21.9%, 17.6%, and 21% in the PFNA, DHS, and PCCP groups, respectively. Total mortality rates were 31.5%, 32.4%, and 29%, respectively. In the literature, the mortality rate remains between 20% and 30% in the year following a hip fracture.[17,18]

We detected that a total of 4 patients had wound infection, 12 patients had the screw cut-out, 7 patients had heterotopic ossification, 11 patients had malunion or nonunion, 1 had a periprosthetic fracture, 1 had implant failure, and 1 had osteolysis with well-fixed implants in the follow-up process. There was no statistically significant difference between the groups in terms of these complications. In addition, the reoperation rates of the groups were similar. Orthopedic complications and reoperation rates remain between 5% and 30% in the literature.[19,20] The present study demonstrated that the mortality, orthopedic complications, and reoperation rates in groups were similar and consistent with the literature.

The LLD usually occurs depending on the femoral neck subsidence after the fixation of proximal femoral fractures, and it adversely affects functional results. Therefore, we only evaluated patients with LLD in the first analysis and did not include patients with LLD in the second analysis, as well as patients with other complications. Zeng et al.[19] reported that DHSs had high LLD rates. Also, our study demonstrated that LLD rates in DHS and PCCP groups were statistically significantly higher than the PFNA group. Although mortality, other complications, and reoperation rates are similar, a low LLD ratio suggests that PFNA is biomechanically superior.

In the present study, no patients had a poor reduction quality, and the number of anatomical reductions was similar in groups. Yu et al.[21] reported that all of their patients had an acceptable or higher quality of reduction with PFNA or DHS. Also, Cheng et al.[22] reported that no patients had a poor reduction quality with DHS or PCCP.

In accordance with the literature,[23] we found that the mean estimated total blood loss and blood transfusion ratio were significantly lower in the PFNA group than in the DHS and PCCP groups. Contrary to the literature,[6] we found that the mean operation and fluoroscopy times were significantly higher in the PCCP group than in the PFNA and DHS groups. Additionally, there was no statistically significant difference between the groups with respect to the duration of hospitalization. This study demonstrated that PCCP was inferior in most of the perioperative properties.

Previous studies reported that patients who had 31A1 fractures may have rather different functional outcomes following fixation with various implants.[19–23] The present study demonstrated that the functional outcomes in the groups were similar and satisfactory, according to the HHS. Previous reports have stated that the union time for these fractures with various implants was 12–18 weeks.[21,24] The average bone healing time in the present study was in accordance with the literature, and there was no statistically significant difference between the groups. It is stated in the literature that maintaining reduction is more difficult with PFNA.[6] Also, we found that PFNA was inferior with respect to the mean NSA changes.

In a cadaveric study, the gluteus medius superomedial footprint area was 501.5 mm² on average.[25] The proximal diameter of the PFNA is 16 mm, and the proximal end area is approximately 201 mm². Therefore, abductor muscles can be damaged during the intramedullary nail insertion through the tip of the greater trochanter. However, the risk of the abductor muscle damage is lower in extramedullary devices such as DHS and PCCP. Stasi et al.[26] indicate that the abductor muscle strength was the main predictor of the functionality of hip fracture patients. In general, previous studies have only assessed the HHS and change in NSA during the follow-up of hip fractures.[27,28] In the literature, to the best of our knowledge, there are no studies comparing intramedullary and extramedullary devices in terms of the AMS loss. One of the advantages of our study was the measured AMS loss on the final follow-up. In the present study, in addition to HHS and changes in NSA, we evaluated the AMS loss. We found that the mean AMS loss was significantly higher in the PFNA group than in the DHS and PCCP groups. Our results suggest that intramedullary nailing significantly damages the abductor muscles during the reaming of the tip of a greater trochanter. Based on our evaluation, although the mortality, reoperation, and other complications rates were similar, PFNA was biomechanically superior to extramedullary devices. PFNA is superior also with regard to most perioperative properties. However, we believe that DHS and PCCP are superior in terms of the NSA change and absent AMS loss.

Despite our informative findings, this study has some limitations, including its retrospective design, a relatively small sample size, as well as the lack of a subgroup analysis of patients according to the fracture pattern, and no post-hoc power analysis. In addition, approximately two-fifths of the patients could not be evaluated on the final follow-up due to mortality, orthopedic complications, or reoperation during the follow-up. Furthermore, if possible, a prospective randomized controlled trial with a larger sample size should be conducted to enhance the statistical power.

Conclusion

To summarize, although PFNA was superior according to the perioperative data and in terms of not causing LLD, DHS and PCCP were superior with regard to maintaining reduction and not causing the AMS loss. All three implants were similar and satisfactory with regard to functional outcomes. Our findings demonstrated that DHS or PCCP can be considered a good primary option to prevent the loss of AMS in elderly patients.

Conflict of interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZET*

Yaşlı hastalarda proksimal femur basit pertrokanterik kırıkların tedavisinde hangi implant üstündür?

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AMAÇ: Bu çalışmanın amacı, basit pertrokanterik kırıklar için proksimal femur antirotasyon çivisinin (PFNA) klinik ve radyolojik sonuçlarını dinamik kalça çivisi (DHS) ve perkütan kompresyon plağı (PCCP) ile karşılaştırmaktır.
GEREÇ VE YÖNTEM: Çalışmaya 203 hasta alındı. Hastaların 73'ünde PFNA (PFNA grubu), 68'inde DHS (DHS grubu) ve 62'sinde PCCP (PCCP grubu) ile fiksasyon yapıldı. Ana sonuç ölçümleri perioperatif özellikler, Harris kalça skoru, boyun-şaft açısının değişimi ve abdüktör kas kuvveti kaybı idi. Veriler gruplar arasında karşılaştırıldı.
BULGULAR: Ortalama tahmini toplam kan kaybı ve kan transfüzyonu alan hasta oranı PFNA grubunda istatistiksel anlamlı olarak düşüktü. Ortalama operasyon ve floroskopi süreleri PCCP grubunda istatistiksel anlamlı olarak yüksekti. Ortalama boyun şaft açısındaki değişim ve abdüktör kas gücü kaybı PFNA grubunda istatistiksel anlamlı olarak yüksekti. Ortalama Harris kalça skorları benzerdi.
TARTIŞMA: Bulgularımız, PFNA'nın perioperatif verilerde üstün olmasına rağmen DHS ve PCCP'nin redüksiyonun ve abdüktör kas gücünün sürdürülmesinde üstün olduğunu göstermiştir. Her üç implant da fonksiyonel sonuçlar açısından benzer ve tatmin edici idi.
Anahtar sözcükler: Fiksasyon cihazları; kalça kırıkları; kırık fiksasyonu; osteosentez.

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