Comparison of clinical results of flattapered and rectangular stems in partial hip replacement based on proximal femur fracture

Proksimal femur kırığında düz-konik ve kare kesit stemler ile yapılan parsiyel kalça protezlerinin klinik sonuçlarının karşılaştırılması

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Abstract

Aim: Hemiarthroplasty is commonly used in proximal femur fractures to provide early mobilization and weight bearing to the patient. Cemented and cementless femoral stems are commonly used in this procedure. Cementless prostheses have many advantages and disadvantages, and their relevance to stem design is controversial. This study aimed to compare flat-tapered and rectangular femoral stems in hemiarthroplasty.

Methods: The study population consisted of a third-level hospital's archive orthopedics and traumatology clinic. Our study was retrospective. A total of 176 patients who underwent cementless hemiarthroplasty in proximal femoral fractures between January 2017 and January 2022 were included in the study. Within these protocols, 64 patients underwent hemiarthroplasty using a flat-tapered stem (Group 1), and 58 patients underwent hemiarthroplasty using a rectangular stem (Group 2). At the last follow-up of the patients, the Harris hip score, Visual Analogue Scale, and early and long-term complications were evaluated.

Results: No significant differences among the patients were observed regarding Harris hip scores and Visual Analogue Scale values. The study groups were analyzed in terms of developing complications. Similar results were found in both groups regarding periprosthetic femur fractures.

Conclusion: Our study found no significant difference between flat-tapered and rectangular stems in terms of clinical outcomes and periprosthetic femur fracture in cases of cementless hemiarthroplasty. As a result, rectangular stems can be safely preferred in hemiarthroplasty.

Keywords: Femoral neck fractures; hemiarthroplasty; hip prosthesis; periprosthetic fractures

Öz

Amaç: Hemiartroplasti, proksimal femur kırıklarında da hastaya erken mobilizasyon ve yük verme olanağı sağlamak amacıyla sık kullanılan bir yöntemdir. Bu prosedürde yaygın olarak çimentolu ve çimentosuz femoral gövdeler kullanılır. Çimentosuz protezlerin birçok avantajı ve dezavantajı vardır ve gövde tasarımıyla ilişkisi tartışmalıdır. Bu çalışmanın amacı hemiartroplastide konik ve kare kesit femur gövdelerini karşılaştırmaktır.

Yöntemler: Araştırma, üçüncü basamak bir hastanenin ortopedi ve travmatoloji kliniğinin arşivinden oluşturulan, retrospektif bir çalışmadır. Proksimal femur kırığı tanısıyla 2017- 2022 yıllarında çimentosuz hemiartroplasti uygulanan 64 konik (Grup 1) ve 58 kare kesit stem (Grup 2) olmak üzere toplam 176 hastaya hemiartroplasti uygulanan hasta çalışmaya dahil edildi. Hastaların son kontrollerinde Harris kalça skoru, Visual Analogue Scale ve erken ve geç dönem komplikasyonları değerlendirildi.

Bulgular: Gruplar arasında Harris kalça skoru ve Visual Analogue Scale değerleri açısından anlamlı fark gözlenmedi. Periprostetik kırıklar açısından karşılaştırıldığında her iki grupta da benzer sonuçlar elde edildi.

Sonuç: Çalışmamızda çimentosuz hemiartroplasti olgularında konik gövde ve kare kesit gövde arasında klinik sonuçlar ve periprostetik femur kırığı açısından anlamlı bir fark bulunmamıştır. Bu nedenle proksimal femur kırığı zemininde kare kesit femoral stem ile yapılan hemiartroplasti prosedürü güvenli bir yöntem olarak kabul edilmektedir.

Anahtar Sözcükler: Hemiartroplasti; femoral boyun kırıkları; kalça protezleri; protez çevresi kırıklar

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INTRODUCTION

Partial hip arthroplasty (hemiarthroplasty) is a surgical procedure in which the femoral side of the hip joint is restored with an implant. This procedure is usually performed in patients who experience chronic hip pain and limited hip joint mobility due to primary and secondary (often rheumatological diseases) osteoarthritis or neglected dysplasia of the hip (1). Hip arthroplasty is also a preferred treatment method for proximal femur fractures to provide early mobilization and weight bearing for the patient who has additional morbidities. This procedure can be applied as hemiarthroplasty or total hip arthroplasty (2). Although cemented stem is commonly used in hemiarthroplasty surgeries, perioperative hemodynamic problems caused by cement application can limit the indication. On the other hand, uncemented hemiarthroplasty surgeries create some concerns, such as osteointegration problems in osteoporotic patients and perioperative fracture risk. (3-6).

Standard flat-tapered porous-coated prostheses are used safely in this surgery. Still, there are cases where these prostheses with proximal involvement cannot provide sufficient stability in patients with poor bone quality. Another alternative femoral prosthesis is rectangular stems with a square section, and the entire prosthesis is covered with a sandblasting technique. The advantage of this method is that it is more stable as it provides both proximal and distal retention. However, some publications argue that the difficulty in adapting the geometry to the normal femoral anatomy may cause fractures around the prosthesis more frequently in these patients, who are often osteoporotic, in the perioperative and early postoperative period (3,4,7,8).

The aim of our study is to compare and reveal the difference between rectangular femoral stems and flat tapered stems in terms of complication rates and clinical outcomes in hemiarthroplasty surgeries for femoral neck fractures.

MATERIAL AND METHODS

Study Population

The study population comprised an archive of hip arthroplasties performed in the orthopedics and traumatology clinic of a third-level hospital where the study was conducted.

Study Design and Participants

Our study was retrospective. A total of 176 patients who underwent cementless hemiarthroplasty in proximal femoral fractures in the orthopedics and traumatology clinic between January 2017 and January 2022 were included in the study. Participants were selected using the posterolateral approach and were followed up for at least one year.

Inclusion Criteria

- >65 years old
- Patients who underwent cementless partial hip arthroplasty with proximal femur fracture Exclusion Criteria
- Follow-up of less than one year
- Those who had previous surgery on the same side
- Unmanaged neurological/psychiatric disorders
- Chronic renal insufficiency
- Those with drug addiction or substance use for any reason

In our clinic, the patient files of all patients planned to undergo surgery after standard proximal femur fracture protocols are filled out in detail due to clinical follow-up and legal obligations. Following the pre-operative anesthesia examination before the operation, the patient's demographic information, the approach to be used for the patient, and the implant selection are made on the same day and recorded in the preoperative list.

Within these protocols, 64 patients underwent hemiarthroplasty using a flat-tapered stem (Group 1), and 58 patients underwent hemiarthroplasty using a rectangular stem (Group 2).

Standard follow-up of patients who underwent hip replacement surgery because of proximal femur fracture:

Postoperatively, on days 1, 2, and 3, standard inpatient assessments were conducted. Subsequently, evaluations were performed on the 10th and 20th days, the 6th week, and the 3rd, 6th, and 12th months following the surgery. Comprehensive outpatient follow-up and assessments were performed. Routine follow-up procedures were continued annually.

During the postoperative period, the joint range of motion is provided and recorded with the standard rehabilitation program on the 1st, 2nd, and 3rd days of the postoperative period.

Superficial and deep soft tissue complications and treatments performed during the patients' 1st, 2nd, and 3rd day hospitalization period in the postoperative period are recorded in the same system.

The patient's Visual Analog Score (VAS), pain scores, and Harris Hip Score (HHS) were recorded at their 1st-year follow-up in the postoperative period.

Two groups were identified in this retrospective study:

Group 1: Partial hip replacement with flat-tapered femoral stem (Figure 1).

Group 2 Partial hip replacement with a rectangular femoral stem (Figure 2).

Surgical Technique

All participants included in the study were prepared for the operation by undergoing lateral decubitus position application under spinal anesthesia. Following the standard sterilization procedure, a posterior-lateralhip incision was made, and the skin and subcutaneous tissue were dissected. Subsequently, access to the hip joint was achieved through a posterior approach. The hip is dislocated, and the broken femoral head is removed with the help of a corkscrew. Femoral neck cutting is performed when necessary. Then, rasping is performed with a rectangular or flat system. The femoral component is hammered. After the femoral component was applied, a stabilization was examined after reduction. In doubtful cases, fracture control is performed using fluoroscopy. After bleeding control and drain application, the capsule and soft tissue are closed, and the operation is terminated.

Data

- The research data are as follows:
- Age, body mass index (BMI), and the side on which the surgery was performed.
- Intraoperative and early postoperative periprosthetic femoral fracture (PFF).
- Soft tissue complications were recorded, including superficial infections, deep joint infections, hematomas, tissue degradation, and their timing and treatment processes.
- During the postoperative period, the patient's last follow-up VAS values and HHS were recorded.

The primary outcome is to evaluate periprosthetic femur fracture incidence in the intraoperative and early postoperative periods in both groups.

The second outcome is giving the clinical and functional scores of each patient group by using VAS and HHS scores at the last follow-up.

Ethics

This study was approved by the Clinical Research Ethics Committee of Kırsehir Ahi Evran University Faculty of Medicine (date: 05.09.2023, decision no: 2023-15/101)

Statistics

The analyses of research data were conducted using the SPSS Statistics for Windows (Statistical Package for the Social Sciences package program version 26.0, IBM Corp., Armonk, N.Y., USA). Descriptive findings are presented in frequency, percentage, minimum/ maximum values, mean, standard deviation, and median values. The normal distribution compatibility of the data of variables was examined using the Shapiro-Wilk test. The t-test or the Mann–Whitney U test was administered to compare two independent groups. In analyzing two repeated measurements, recourse was made to the paired t-test or the Wilcoxon signedrank test. Relationships among categorical variables were explored using the chi-square test. A significance threshold of $p<0.05$ was adopted to denote statistical significance in the analyses.

RESULTS

The findings regarding the analyzed variables and demographic data of the entire patient population in our study are given in tables (Table 1, 2).

It was determined that age, BMI, and follow-up period values had a similar distribution between our study groups, and there was no significant difference between them. HHS and VAS values were compared between the groups at the final controls. It was determined that there was no statistical difference between the variables in the measurements of the patients (Table 3).

Complications

There was no statistically significant relationship regarding complications between the groups (p=0.891) (Table 4). In the flat-tapered stem group, four patients had frac-

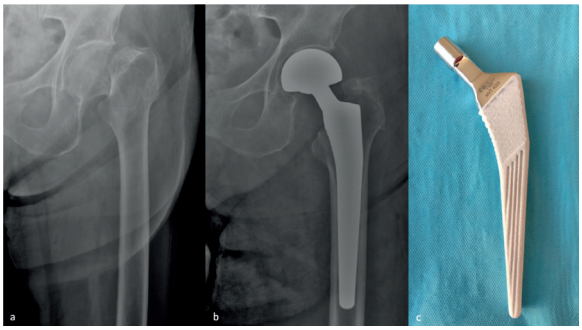

Figure 1. Radiographs of an 81-year-old woman with a proximal femur fracture
a) preoperative anteroposterior view b) early anteroposterior postoperative radiographs, hemiarthroplasty was performed with a flat-tapered stem c) photo of flat-tapered stem

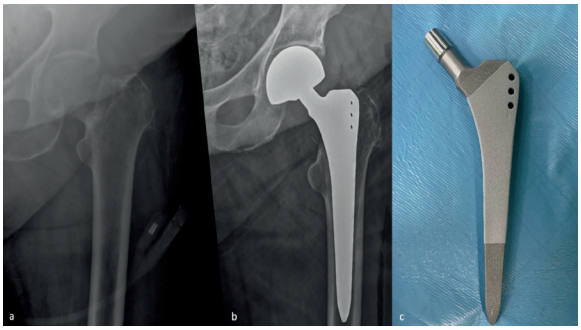

Figure 2. Radiographs of an 84-year-old woman with proximal femur fracture a) preoperative anteroposterior view b) early anteroposterior postoperative radiographs, hemiarthroplasty was performed with a rectangular stem c) photo of rectangular stem

tures intraoperatively, and two patients had fractures in the early postoperative period. Intraoperative fractures were treated using perioperative interventions. One of the early postoperative fractures was around the greater trochanter, which was reoperated, and osteosynthesis was performed with trochanteric plates and cables (Figure 3). The other patient was treated conservatively by walking without weight bearing.

In the rectangular stem group, three patients had fractures during surgery, and two had fractures in the early postoperative period. Intraoperative fractures and two femoral cracks were treated with perioperative interventions (Figure 4). The patient with an early postoperative fracture had a fracture extending to the medial calcar. Therefore, the procedure was revised with a long modular stem because the stability of the prosthesis was impaired.

During the short follow-up of the patients, no aseptic loosening was observed in either group. No patient underwent revision surgery due to implant loosening. Implant survival was similar in both groups.

In the flat-tapered stem group, dislocation was detected in two patients, hematoma requiring drainage in one patient, and prolonged serous discharge in three patients. Hip dislocations were treated by closed reduction and revision surgery for each patient. A stable hip was achieved in this surgically treated patient by using the dual mobile acetabular component. Three patients in the rectangular stem group had dislocations, and two had prolonged serous discharge. In three of the dislocations, treatment was completed with closed reduction. Periprosthetic joint infection

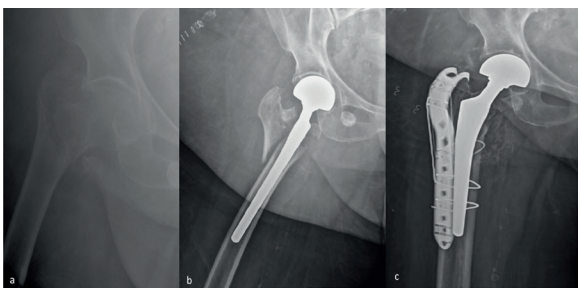

Figure 3. Radiographs of a 92-year-old woman with proximal femur fracture a) preoperative anteroposterior view b) early anteroposterior postoperative radiographs, postoperative fracture was around the greater trochanter c) periprosthetic femur fracture was reoperated and osteosynthesis was performed with trochanteric plates and cables

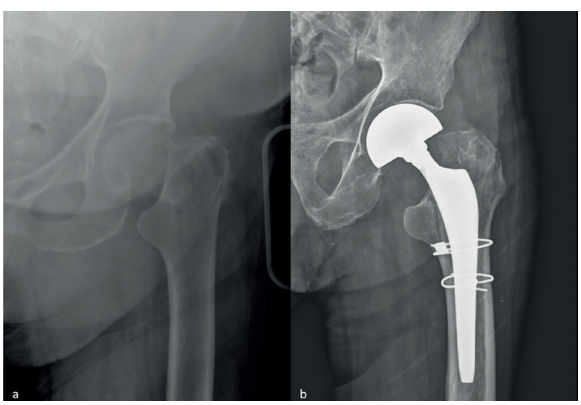

Figure 4. Radiographs of an 88-year-old woman with proximal femur fracture a) preoperative anteroposterior view b) early anteroposterior postoperative radiographs, intraoperative fractures were treated with two cables

(PJI) was observed in 2 patients in the flat tapered stem group and one in the rectangular group. Early DAIR (debridement, antibiotics, and implant retention) was performed in 3 patients and suppressed by appropriate antibiotic therapy.

Table 1. Demographic data

		n	%
Gender	Female	68	55,7
	Male	54	44,3
Group	Flat	64	46,2
	Rectangular	58	53,8
Side	Left	55	45,1
	Right	67	54,9

n: Number, %: Percent

Table 2. Demographic data and clinical parameters

	Min	**Max**	**Mean±SD**
Age	66	92	81,50±6,20
BMI (kg/m²)	21,2	38,9	29,26±4,78
Follow up (months)	14	74	29,52±18,22
Last follow up HHS	42	90	78,2±8,7
Last follow up VAS	0	7	3,31±1,32

*Min: Minimum, Max: Maximum, SD: Standard deviation, BMI: Body mass index, HHS: Harris hip score, VAS: Visual analog scale

Table 3. Comparison of data in the groups

	Flat-tapered (n=64)	Rectangular (n=58)	p
HHS	77,5±8,3	79,4±8,4	0,633
VAS	3,4±1,1	3,2±1,2	0,228
BMI	28,42±4,52	29,86±4,81	0,882
Age	82,60±5,90	80,20±6,40	0,771
Follow Up	28,74±17,84	29,96±18,41	0,556

*n: Number, HHS: Harris hip score, VAS: Visual analog scale, BMI : Body mass index, p<0.05

Table 4. Incidence of periprosthetic femoral fractures by femoral stem types

Type of The Femoral Stem	Number of PFF* (%)	Mean Months to PFF (Range)	Any Reoperation for PFF (%)	Revision of PFF (%)
Flat-Tapered Stems (n:64)	6 (9.3)	37 (14-64)	1(1.5)	-
Rectangular Taper Stems (n.58)	5(8.6)	35 (13-62)	1(1.7)	1(1.7)

*PFF, periprosthetic femoral fracture. n: Number

DISCUSSION AND CONCLUSION

PFF is a preventable but important complication that can occur during and after cementless hip replacement. There are various risk factors for intraoperative PFFs, including advanced age, poor bone quality, and surgeon's operative volume (9). Implant design is another important factor affecting fracture risk (10-13). In the literature, PFF has often been studied in THA cases. However, few studies are available on intraoperative complications during hemiarthroplasty for femoral neck fractures. Because most studies reporting PFF rates in THA femoral side fractures are studied, it can be a reference in cementless hemiarthroplasty cases. However, patients with femoral neck fractures constitute a very different group when compared with those undergoing elective total hip arthroplasty, considering age, bone quality, and additional morbidities.

Several studies have reported a higher PFF rate in hip arthroplasty using rectangular stems. It was

stated that the main reason for this may be geometric features. Although the rectangular section provides initial support, this angular structure can also be an additional stressor. When a rotational force is applied to the stem, this force can transform into a sudden increase in rotational stress in the femoral canal, causing PFF (7,14-16). Our study found no significant difference between flat-tapered and rectangular stems in terms of clinical outcomes and PFF in cases of cementless hemiarthroplasty.

Jeong et al. compared the PFF rates of flat-tapered, rectangular, and quadrangular stems in more than three thousand cementless total hip prostheses. It was concluded that rectangular stems have a higher risk of PFF than the other stems. However, two of these stems were compared in our study, and no such difference was found. This can be explained by the fact that the patient population is different (7).

Han et al. analyzed PFF types in cases with rectangular stems and found that the long spiral break was significantly greater in this design. However, their design makes typical rectangular stems more likely to be placed in the varus position (17). A systematic study detected 10.6% varus malposition in cases made with rectangular stems. Varus malposition may be an independent risk factor for implant loosening and PFF because it creates abnormal stress distribution and poor implant placement (18,19).

Ohly et al. reported the incidence of PFF to be 5.4% in a large uncemented hip arthroplasty case series (20). Similarly, Ricioli et al. reported that the incidence of intraoperative PFF was 5.39% in the cementless study group (21). Compared with these studies, although the incidence rate of intraoperative PFF was slightly higher in our study, this result seems normal because the patient group in our study was elderly and had poor bone quality.

Chandran et al. conducted a retrospective study of hemiarthroplasty with a cementless femoral stem in 65 patients diagnosed with collum femoris fracture. The results of the series reporting 12 (7.2%) patients with PFF at the end of a 1-year follow-up period are closely similar to the rate in our total patient population. It has been reported that 7 cases were in the preparation phase of the femur, and 5 cases were in the implantation phase. All cases were stable, with fixations made with cerclage in the perioperative period, and there was no need for femoral revision. As in our study, it has been reported that patients with this type of intraoperative intervention were rehabilitated by walking with partial load for six weeks. Unlike in our study, PFF was detected in four patients in the early postoperative period, but it was not found in this series. This is because early postoperative PFFs in both groups are cases of femoral cracks that were overlooked and untreated with cerclage (22).

The proximal femur should be prepared to fit the implant well. It has been argued that femur geometry and material properties affect stress distribution (23). Similar fractures occur during the preparation and implantation of the femoral canal (22). Liu et al. found 3.2% PPF in their case series. They found that most of these fractures were in preparation before prosthesis implantation. Iatrogenic fractures may occur as a result of force applied during rasp insertion while preparing the medullary canal. Therefore, when there is difficulty in the preparation phase of the prosthesis, they recommend that the rasp is repositioned in the correct position instead of increasing the strength, and re-rasping should be carefully continued (3). Our study suggests that the medial part of the trochanter major should be carefully removed with a chisel while proceeding to the preparation stage with a rasp in a patient who will use a rectangular stem. We argue that removing this part, on which the lateral part of the rasp rests, prevents pertrochanteric fractures.

Fitzgerald et al. focused on preoperative planning and templating. As a result, they reported 6.3% of intraoperative fractures, all involving the proximal femur, and concluded that 3.5% of femur fractures could be prevented by creating a preoperative x-ray template (24). Most fractures occur during the implantation of the prosthesis into the femoral canal. Preoperative planning according to the geometry of the femur and canal structure and selecting the appropriate implant are the most important preventive factors.

Many articles compare cemented and cementless hemiarthroplasty series. The general opinion is that similar results are observed regarding early functional outcomes. However, it has been reported that intraoperative complications are significantly higher in cemented hemiarthroplasty cases and early complications related to the implant in cementless stem applications (25,26). However, the literature has reported that

cemented hemiarthroplasty cases are more successful in terms of early functional outcomes and pain. In addition, Azegami et al.'s meta-analysis strongly emphasized that there is no difference between cementless hemiarthroplasty and cementless hemiarthroplasty in terms of mortality and complications (27).

It has been reported that the risk of PFF in the first three months after arthroplasty with uncemented stems is four times higher than that with cemented stems (4-6). Brodén et al. examined 1403 hips with cemented femoral stems in a large single-center case series and found a PFF rate of 3.3%. This produced PFF in half of our series of patients with cementless stems and is consistent with the literature (28). There was no significant difference between the two groups in terms of the HHS and VAS values used for clinical evaluation. In the literature, the success of cementless hemiarthroplasty in proximal femur fractures has been accepted in large patient series and long-term follow-ups. When both groups were examined in terms of complications other than PFF, the results were similar and consistent with the literature (29-30). In the study performed by Kim et al. in 123 cementless bipolar hemiarthroplasty cases where they performed hemiarthroplasty with entire porous coated rectangular stems in proximal femur fractures, they found an average of HHS 77 (31). It has similar results to our study in terms of complication rates.

Our study has some limitations. First, this study has a retrospective design. This can disrupt randomization in patient selection and the homogeneity of results. Second, although our cohort was a relatively large patient series, different results may have been obtained in the more extensive patient series of this study. Another limitation of our study is the short follow-up period; these surgeries should be evaluated with long-term follow-up studies.

Although publications show that the rectangular stem has higher complication rates, such as PFF, we found that the complication rates and functional results of rectangular stems were not different from those of flat-tapered stems in our study. Therefore, we believe that cementless hemiarthroplasty procedures with rectangular stems are safe in elderly patients with proximal femur fractures. Preoperative planning and patient selection play a key role in success.

Conflict-of-interest and financial disclosure

The authors declare that they have no conflict of interest to disclose. The authors also declare that they did not receive any financial support for the study.

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