

Clinical outcomes of treatment with free vascularized fibular flap in avascular necrosis of the femoral head

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ABSTRACT

Objective: Research of the clinical results of patients diagnosed with avascular necrosis of the femoral head and treated with free vascularized fibular flap.

Methods: Thirteen hip joints of 10 patients who were treated with vascularized fibula for the diagnosis of avascular necrosis of the femoral head were inspected. Stage of disease was grouped according to the Steinberg staging system, and stage II-III patients underwent free vascularized fibular flap surgery. Preoperative and postoperative Harris hip score, VAS scores, and Steinberg stages of the patients were compared.

Results: The patients were followed for an average of 28 months (range 7 to 42). Pre-operative and post-operative Harris hip score of the patients were found to be 55.2 and 95.3 on average, respectively ($p < 0.05$). The pre-operative and post-operative mean VAS score was found to be 7.07 and 0.61, respectively ($p < 0.05$) and a significant decrease was observed. While the pre-operative stage of the patients was 2.2 on average, the stage detected in the last control was monitored as an average of 1.7 ($p < 0.05$) and a significant decrease was recorded.

Conclusion: In patients with early stage avascular necrosis of the femoral head, if surgical treatment is performed with free vascularized fibular flap, the development of degenerative arthritis is prevented and the need for total hip arthroplasty is reduced. In addition, the hip joint functions are preserved and allows to patients for painless motion.

Key words: Avascular necrosis of femoral head, Harris hip score, free vascularized fibular flap, Steinberg classification

Introduction

Avascular necrosis of femoral head is a progressive disease that is generally encountered in individuals between the ages of 30-50 and results in a high rate of total hip arthroplasty if left untreated. The annual incidence of osteonecrosis in the USA is 10.000 cases and still, 10% of total hip arthroplasties (THA) performed

in this country are performed for this reason [1].

In treatment; joint protective methods are preferred in cases with early diagnosis, and total joint arthroplasty are performed in late-diagnosed advanced cases [2-12]. Among these procedures, free vascularized fibular flap technic is used more frequently and gets more popularity day by day. Urbaniak et al. attrib-

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uted the rationale underlying vascularized fibular flap technic to 4 main items.

These are;

I. Femoral head decompression to break down the ischemia cycle and prevent increased intraosseous pressure,

II. Removal of necrotic bone that may prevent revascularization of the femoral head,

III. Filling the defect with the graft, supporting the subchondral surface,

IV. Preservation of recovery by limiting weight-bearing after surgery [8].

In this study, we aimed to search the effects of free vascularized fibular flap treatment on the disease process in patients with early stage avascular necrosis of femoral head and to evaluate and compare the functional status of the patients before and after surgery.

Patients and Methods

Between January 2009 and March 2013, the data of 15 patients who applied to Orthopedics and Traumatology polyclinic and were diagnosed with avascular necrosis of femoral head and underwent surgical treatment with free vascularized fibular flap were retrospectively reviewed. Thirteen operated hip joints of 10 patients who came to the last control and met the inclusion criteria were evaluated. Preoperative and postoperative Harris hip score, visual analog pain scale (VAS score), and avascular necrosis stage were determined separately for each operated hip of the patients included in the study. According to these criteria, we compared pre-operative and post-operative pain scores, staging, and functional results of the patients. This study was performed in line with the principles of the Declaration of Helsinki and approval was granted by the Ethics Committee.

The staging of the patients diagnosed with avascular necrosis of the femoral head as a result of physical examination, pelvis radiography, and MR was made according to the Steinberg Classification. Stage 2 and stage 3 patients who underwent surgical treatment and

had at least 6 months of follow-up in the post-operative period were included in the study. According to Steinberg Classification; cystic and sclerotic changes in femoral head are seen in stage 2, and subchondral collapse without flattening (crescent sign) is seen in stage 3, respectively [13]. Stage 1, stage 4-6 patients, those with infection in the recipient or donor site, patients with systemic severe disease such as severe heart failure and chronic kidney failure were excluded from the study. Pelvis radiography (Figure 1-A), orthogonal views of tibia, MRI of the hip (Figure 1-B, 1-C) and angiography of the extremity (Figure 1-D) were obtained in all patients undergoing surgery. We wanted to see preoperative angiography in all patients, because we needed to make sure that peroneal arterial circulation was intact in order to provide sufficient blood supply on the recipient side.

Surgical Technique and Post-operative Period

The patients were placed in the lateral decubitus position and a lateral longitudinal incision was performed. The tensor fascia lata was pulled anteriorly, then the vastus lateralis and vastus intermedius were cut off where they were attached. The ascending branches of the lateral femoral circumflex artery and lateral femoral circumflex vein, which runs between the rectus femoris and the vastus lateralis, were explored and preserved. A guide kirschner wire from 2 cm distal to the trochanter major sent under fluoroscopy control towards the anterosuperior area of the femoral head (Figure 2). Then, the channel was expanded to 20 mm by cannulated reamers and the necrotic area was scraped with a curette. Spongy graft was taken. After that, vascularised fibular flap was taken as described by Urbaniak et al. [14]. Afterward, cancellous grafts were sent to the femoral head through the tunnel in the femoral head and the prepared fibula pedicle was turned distally, and the fibular flap sent toward the femoral head. It was fixed with a k-wire. Afterward, firstly peroneal artery and ascending branch of the lateral circumflex artery, and after that peroneal vein and ascending branch of

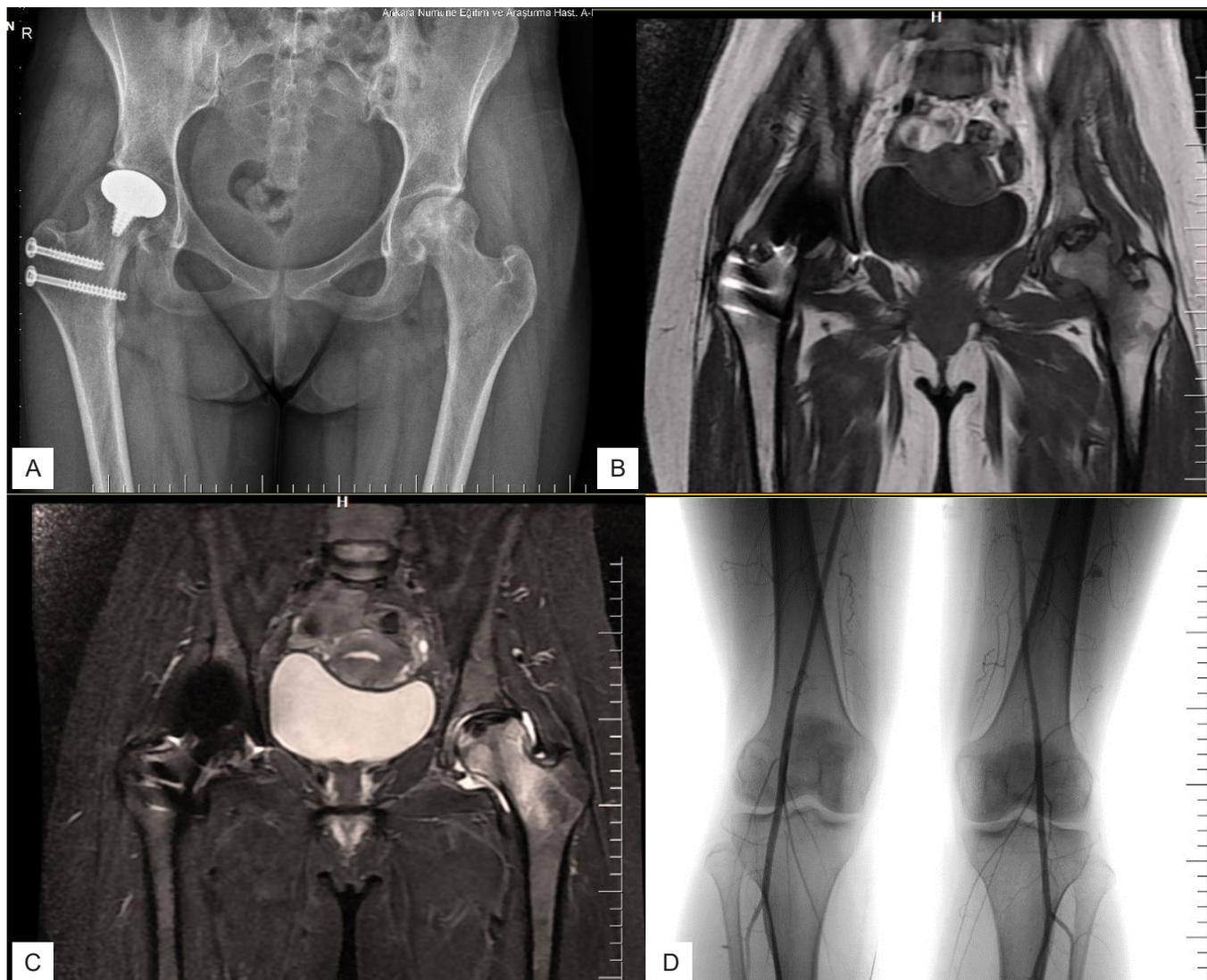


Figure 1. A 38-year-old female who had bilateral avascular necrosis of femoral head and underwent resurfacing arthroplasty on her right hip in another hospital, was admitted to our clinic with left hip pain. As a result of the examinations, the diagnosis of stage 2 avascular necrosis of femoral head was made in the left hip, and surgical treatment was planned with a vascularized fibular flap. **(A)** Plain radiograph of the pelvis, demonstrates cystic and sclerotic changes in femoral head, there was no collapse **(B)** Pelvis MRI, shows typical band-like pattern of avascular necrosis lesion in T1W and **(C)** in T2W **(D)** Lower extremity angiography, shows the intact peroneal arterial circulation.

the lateral circumflex vein were anastomosed end-to-end with 9.0 ethylon.

On the 1st postoperative day, patients were mobilized with a pair of crutches without weight bearing on the operated limb. The patients were not allowed to weight-bearing on the operated leg for 3 months after the surgery. Full weight-bearing was allowed after 3 months. In the postoperative 3rd and 6th weeks, and after that 3rd and 6th months polyclinic controls were made of the patients. Patients who did not have

any complaints in the following periods were called for control once a year.

Outcome Assessment and Statistical Analysis

The results of the study were evaluated using the SPSS program. Pre-operative and post-operative final control findings of the patients were compared using the Wilcoxon test and spearman's correlation coefficient statistical methods. A p-value of less than 0.05 was considered statistically significant.

Preoperative and postoperative functional status

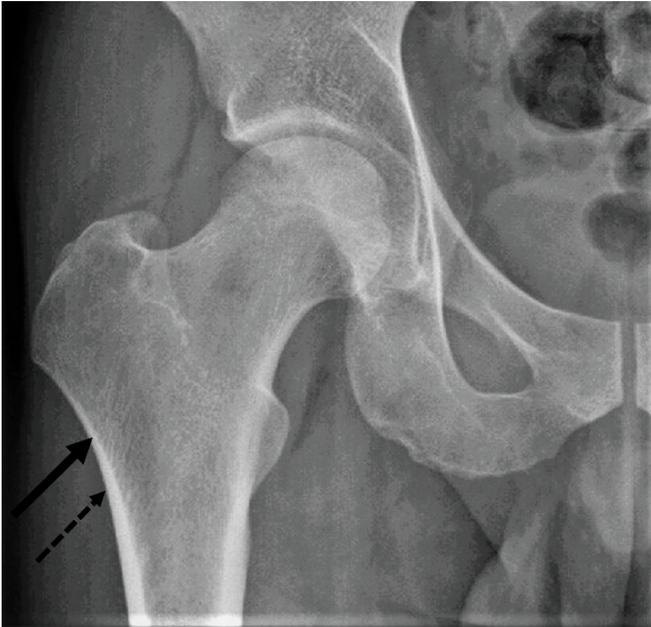


Figure 2. Core decompression entry point. **Thick arrow:** Optimal entry point. **Broken thin arrow:** Distal entrance (high risk of fracture).

and activity levels of the patients were evaluated with the Harris hip score, the pain assessment was made according to visual analog pain scale (VAS), staging of the patients was done according to the Steinberg staging system, respectively [13]. Harris hip scores of the patients were calculated by the same investigator. Patients were allowed to fill in the visual analog pain scales themselves. To ensure inter-observer reliability; each patient's stage was determined by two independent orthopedists. Patients who reported the same stage as a result of staging were included in the study. Patients in whom two investigators had different decisions on the stage were excluded from the study.

Results

The gender, age and etiological factor distribution of the patients included in the study is summarized in table 1. The mean pre-operative Harris hip score of the patients was 55.2 ± 7.9 and the median was 55 (range 42 to 68). The mean pre-operative VAS score was 7.07 ± 1.11 , and the median value was 7 (range 5 to 9). When the pre-operative stages are evaluated; 10 hips were determined as stage 2, and 3 hips as stage 3. The mean stage was evaluated as 2.23 ± 0.44 before the operation.

Corticosteroid use in 4 hips and sickle cell anemia in 2 hips were identified as etiological factors. No etiological factor could be found in 7 hips and it was accepted as idiopathic avascular necrosis of femoral head. It was observed that an average of 6 ± 2.85 (range 2 to 12) months passed between the diagnosis of the patients and the duration of the operation. None of the patients had any donor site complications.

The mean total operation time was 195 minutes. The mean fibular flap harvesting time was 85 minutes, while vessel anastomosis time was 52 minutes.

The patients were discharged after a mean hospital stay of 7.46 ± 0.87 (range 7 to 10) days postoperatively. The shortest follow-up period was 7 months and the longest 42 months (mean 28 months) after surgery.

Post-operative Harris hip score were calculated as 95.3 ± 1.5 (range 92 to 97). Excellent results were achieved in all patients. A statistically significant increase was found in the Harris hip score of the patients ($p=0.005$) (Table 2).

The mean VAS scores of the patients to a value between 0.61 ± 0.76 (range 0 to 2). A statistically significant improvement was observed in the pain of the patients ($p=0.01$) (Table 2).

There were no patients with stage 3 and above at the time of last control. Four of the patients were determined as stage 1, and nine of them were determined as stage 2. There was no progress in the stage of any pa-

Table 1. Demographic characteristics and distribution according to etiological factor of the patients.

Variable		Male (%)	Female (%)	Total (%)
Number of Case		8 (%61.5)	5 (%38.5)	13 (100)
Mean Age \pm SD (Range)		34.7 ± 8.5 (21-52)	35 ± 10 (18-45)	$34.8 \pm 9,1$ (18-52)
Side	Right	3	3	6
	Left	5	2	7
Etiological Factor				
Idiopathic		5	2	7
Corticosteroid		3	1	4
Sickle Cell Anemia		0	2	2

Table 2. Pre and Post-operative Harris Hip Scores and Steinberg Stages.

		Pre operative	Post operative	P
Harris Hip Score	Mean±SD	55.2 ± 7.9	95.3 ± 1.5	0.01
	Median (Range)	55 (42-68)	96 (92-97)	
Harris Hip Score Result	Excellent	0	13	0.005
	Good	0	0	
	Fair	0	0	
	Poor	13	0	
VAS Score	Mean±SD	7.07±1.11	0.61±0.76	0.01
	Median (Range)	7 (5-9)	0 (0-2)	
Steinberg Classification	Stage 1	0	4	0.08
	Stage 2	10	9	
	Stage 3	3	0	
	Mean stage±SD	2.2 ± 0.43	1.7 ± 0.48	

tient, the stage of 6 patients (46%) remained constant, and the stage of 7 patients (54%) improved. THA (total hip arthroplasty) was not applied to any patient. The hip joint was preserved in all patients. While the pre-operative stage of the patients was 2.2 ± 0.43 (2-3), it was determined as 1.7 ± 0.48 (1-2) in the post-operative period. A statistically significant improvement was observed ($p = 0.08$) (Table 2).

The pre-operative and post-operative direct radiographs of a patient who had a pre-operative stage 2 (Figure 3-A) and whose stage did not progress after 1 year of follow-up are shown in Figure 3-B.

No significant relationship was found between the time between diagnosis and operation, and improvement in Harris hip score, decrease in VAS scores or improvement in disease stage ($p > 0.05$)

When the improvement between gender and Harris hip score was examined, it was found that there was a more significant improvement in women compared to men ($p = 0.03$). No relationship was found between gender and VAS scores or improvement of the stage ($p > 0.05$) (Table 3).

A significant relationship could not be found between the sides of the operated hips and the improve-



Figure 3. (A) Pre operative x ray of 38-year-old female who underwent vascularized fibular flap surgery, her left hip was Steinberg stage II before surgery (B) After operation 1 year follow up x ray, left hip was still stage II.

ment in Harris hip score, VAS score, and stages ($p > 0.05$) (Table 3).

Discussion

According to the results of our study, a statistically significant difference was found in terms of Harris Scores, VAS scores and staging between before and after surgery.

There are studies examining the difference in clinical outcomes between surgical and conservative treatment. In a meta-analysis, includes 21 study, conserva-

Table 3. Relationship between gender and operated side with change in Harris Hip Score, change in VAS and improvement of the stage.

Variable	Harris Hip Score		VAS Score		Steinberg Stage		
	Mean \pm SD	Median (Range)	Mean \pm SD	Median (Range)	Mean \pm SD	Median (Range)	
Side	Right	43.3 \pm 7.8	43 (34-54)	-6.8 \pm 0.75	-7 (-8 -6)	-0.83 \pm 0.4	-1 (-1 0)
	Left	37.2 \pm 7.4	37 (29-49)	-6.1 \pm 1.57	-6 (-9 -4)	-0.28 \pm 0.4	0 (-1 0)
	P	0.181		0.234		0.101	
Gender	Male	36.5 \pm 6.7	35 (29-49)	-6.25 \pm 1.48	-6 (-9 -4)	-0.50 \pm 0.53	-0.5 (-1- 0)
	Female	45.8 \pm 6.5	45 (37-54)	-6.8 \pm 0.83	-7 (-8 -6)	-0.6 \pm 0.54	-1 (-1-0)
	P	0.030		0.435		0.833	

tively treated 819 hips, published by Mont et al. only 182 (22%) hips could be considered successful [15]. It can be concluded that surgical treatment is superior in patients with avascular necrosis, even at stage 1.

One of the most important criteria showing the success of this treatment is the regression of the stage of the disease or at least the ability to stop its progress. Soucacos et al. in their study, 184 hips (152 patients) underwent vascularized fibula surgery, and the patients were followed for an average of 4.7 years. In that study; both regression of the stage of the disease after the operation, the rate of going to hip prosthesis and in which patient group more successful results was obtained, are reported. While the disease did not progress in 101 of 184 hips (54%), THA was applied to 14 hips (8%). The highest success rate was achieved in stage 2 patients and the lowest success was seen in patients with stage 5 [16]. In a similar study, where Cho applied surgery 30 hips of 26 patients and followed up for an average of 21 months. Direct radiographs of 2 patients whose pain was worsened, advanced femoral head depression was observed in the patients, and these patients were in pre-operative stage 3 and stage 4 [17]. According to these studies, free vascularized fibular surgery in the early stages is a very successful method, while the success of the treatment decreases in the patients which have progressed stage. In our study, while this surgery was applied to Steinberg stage 2 and 3 patients, we did not recommend this method to patients with stage 4-5-6. In our study, stage of the patient regressed or re-

mained stable with a rate of 100%.

The effects of vascularized fibular flap and non-vascularized fibula graft, which are two very similar surgical methods, on clinical results have been a matter of curiosity. Kim compared outcomes of two surgery method. Both groups consisted of 23 hips of 19 patients and the patients were followed up for an average of 4 years. While the Harris hip score increased by 70% in patients treated with vascularized fibular flap, it increased by 35% in the non vascularized group. While the femoral head collapsed an average of 2.8 mm in the vascularized group, the mean amount of collapse was 4.3 mm in the non-vascularized group. While THA was performed to 3 patients in the vascularized group as a result of follow-up, this number was 5 in the non-vascularized group [18]. Similarly, Tetik et al. observed that the mean Harris hip score increased significantly more in the vascularized group than the nonvascularized group [19]. Plakseychuk et al. in a study comparing vascularized and non-vascular grafts, no collapse was reported as 86% and 30%, a significant improvement in Harris hip score 70% and 36%, and radiological progression as 24% and 72%, respectively in a 7-year follow-up [20]. According to the results of these studies, vascularized fibular flap is superior to the non-vascularized fibula method. We attribute this difference to the anastomosis of artery and vein. We think that the performed anastomose supports the microvascular structure inside the femoral head and provides nourishment of the femoral head.

There are some alternative vascularised bone flaps, like free vascularized iliac bone flap or pedicled iliac bone flap. The clinical outcomes of these surgical procedures seems similar with vascularised fibular flap. But if the vascularized iliac graft is compared with the vascularized fibular flap, even though the cancellous bone structure of the iliac graft is biologically ideal, the demanding anatomy of the donor site and higher complication rate decrease the preference rate of the vascularized iliac crest graft. Nowadays, the vascularized fibular flap is preferred more frequently [21].

In a study researching the vitality of the femoral head after vascularized fibular flap, the radioactivity of the fibular flap was observed with SPECT / CT by Fontecha et al. In that study, this surgical method was applied to 10 hips of 9 patients and they observed that radiotracer was taken in all of the cases and the flap was alive. In addition, the average Harris score was 37.2 pre-operatively, while it increased to 92.3 in the postoperative period [22].

Except for surgical methods, some researches continue to increase the success of surgical treatment. Papakostidis et al. published a review of 7 studies comparing core decompression surgery with core decompression surgery + mesenchymal stem cell implantation. According to the study, patients who underwent mesenchymal stem cell implantation in addition to surgery had higher average Harris hip scores, and the need for total hip prosthesis was less [23]. Wang et al. got similar results in their review, which contains 14 studies and 540 patients [24]. Emadedin et al. published a similar but more specialized study examining the effects of implantation of CD133 cells, harvested from bone marrow. They found a significant increase in Harris scores and a significant decrease in VAS values in the group that underwent core decompression + CD133 cell implantation compared to the group that underwent only core decompression [25]. When we searched the literature, we did not find a study combining vascularized fibular flap with mesenchymal stem

cells. In the future, further studies can be conducted on additional procedures that will increase the success of vascularized fibular flap.

Vascularized bone graft has a definite efficacy in the treatment of avascular necrosis of femoral head, especially in young patients. It can effectively delay or even prevent hip arthroplasty [26]. In cases where this treatment method is unsuccessful, total hip replacement is a very common treatment choice. There are studies investigating how the previous free vascularized fibular flap affects the results of total hip replacement. In the study of Davis et al., clinical and radiographic results of avascular necrosis patients were examined who underwent total hip replacement after free vascularized fibular flap surgery. When the results were examined; radiographically, there is no difference was found between the amount of prosthesis collapsing in hips in the end control radiographs. When hip scores are compared; It was reported that clinical scores were significantly worse in hips undergoing free vascularized fibular surgery [27].

Although this surgical method is a successful method in general, some complications may be seen. Complication rates were examined in Lee's study with 194 hips (158 patients). The risk of subtrochanteric femur fracture is increased especially in patients who are given early weight. In Lee's series, subtrochanteric fractures were observed in 5 (13.9%) of 36 patients who were operated bilaterally, while subtrochanteric fractures were observed in 8 hips (4.1%) in the entire series. According to this study; the fracture rate increases significantly in bilateral cases. Lee reported that no load should be given for 3 months post-operatively [28]. In Gao's study, including 578 cases, donor site complication rate was clarified. Temporary sensory loss of the thigh area in 11 cases (1.9 %), and restricted motion of the great toe in 9 cases (1.6 %) [29]. In the study of Eward, post-operative heterotopic ossification rates were researched and a rate of 4.6 % was observed [30]. We did not permit the patients to weight-bearing after op-

eration for 3 months. No complications were observed in our patients, including subtrochanteric fractures.

In our study, we examined the results of free vascularized fibular flap treatment preferred in early stage avascular necrosis of femoral head and observed its correlation with other studies in the literature. The limitation of this study is the small number of patients and the short duration of our follow-up. More guiding results can be obtained if the number of patients is increased and follow-up periods are extended with future studies.

Vascularized fibular flap surgery is one of the effective treatment modalities for avascular necrosis of femoral head patients that, improves the clinical results and slows down the progression to total hip arthroplasty.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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