



Comparison of early results of vascularized and non-vascularized fibular grafting in the treatment of osteonecrosis of the femoral head

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Objective: Osteonecrosis of the femoral head, a disease primarily affecting young adults, is often associated with the collapse of the articular surface and subsequent arthrosis. Some authors have reported good results with the use of vascularized and non-vascularized fibular grafts to treat osteonecrotic lesions of the femoral head. The aim of this study was to compare the results of vascularized fibular grafting with that of non-vascularized fibular grafting in the treatment of femoral head osteonecrosis.

Methods: Between January 1999 and June 2008, 11 osteonecrotic hips of 8 patients who underwent vascularized fibular grafting and 15 osteonecrotic hips of 13 patients who underwent non-vascularized fibular grafting were compared according to etiology, stage, age, sex, preoperative and postoperative first year Harris hip and VAS scores.

Results: Steroid use was the most common etiologic factor, found in 26 hips of 21 patients in the entire patient population. There was no significant difference between the two groups according to their age, sex and preoperative Harris hip scores ($p>0.05$). According to the Ficat staging system for radiological evaluation, 4 hips were Grade 2A, 4 hips were Grade 2B, and 3 hips were Grade 3 in the vascularized group and 8 hips were Grade 2A, 3 hips Grade 2B, 3 hips Grade 3 and one hip was identified as Grade 4 in the non-vascularized group. When the Harris hip and VAS scores of both groups were evaluated, the group treated by vascularized fibular grafting had significantly higher scores than the ones treated by non-vascularized fibular grafting in the other group ($p<0.05$). Furthermore, when the Harris hip and VAS scores of preoperative and postoperative first year of vascularized fibular grafting patients were compared, there were significantly higher scores after the surgery.

Conclusion: Although there was no significant radiological difference in the early results of both surgical techniques, the clinical results of vascularized fibular grafting treatment were significantly better than the results of non-vascularized fibular grafting treatment in the osteonecrosis of the femoral head. Vascularized fibular grafting improves the clinical status at an early period and prevents subchondral collapse.

Key words: Femur head osteonecrosis; fibular grafting; Ficat staging; vascularized fibular grafting.

Osteonecrosis of the femoral head is also known as avascular or aseptic necrosis. Deterioration of nutrition in a part or the whole of the femoral head is considered the main cause of avascular necrosis. An accurate incidence and prevalence rate is impossible to determine; nevertheless, it is estimated that there are between 15,000 and 20,000 new cases of avascular necrosis in the US every year.^[1]

Patients' first complaint with avascular necrosis of the femoral head is unilateral hip pain, followed by limping and limitation of hip movement. Adults between 30 and 40 years of age are most affected by this disease. If untreated, patients follow a progressive course towards subchondral fractures, collapse and painful arthrosis.^[2-9] Osteonecrosis of the femoral head may affect both hips at a rate of 30% to 50%.^[10]

Osteonecrosis has many etiological factors; alcohol abuse, gout, caisson disease, Gaucher's disease, renal osteodystrophy, hypercoagulability status, drepanocytic anemia, systemic steroid usage, chemotherapy treatment, trauma and rheumatoid arthritis.^[11-13] Most cases, however, are idiopathic.

The accepted theories on the pathogenesis of osteonecrosis are direct cellular toxicity, coagulopathies, fat embolism, vascular anomalies, increased bone marrow pressure, deterioration of mesenchymal cell differentiation, Type 2 collagen anomaly depending on the mutation in autosomal dominant transitive chromosome 12q13, and pleomorphism in the gene of endothelial nitric oxide synthetase.^[14-17] Osteonecrosis is a multi-factorial disorder and these theories cannot explain the entire pathogenesis for all cases.

Although diagnosis is established directly through radiographs, magnetic resonance imaging (MRI) is adjunct in obtaining a diagnosis in the early and asymptomatic phases.^[1,18]

In osteonecrosis of the femoral head, core-decompression^[19-21], electrostimulation^[22,23], transtrochanteric rotational osteotomies^[24] and vascularized or non-vascularized fibular grafting are the available treatment options.^[25-30]

Vascularized fibular grafts are used to halt the progress of necrosis and extend re-vascularization.^[31-35]

Patients and methods

In this prospective study, the results of 11 femoral head osteonecrotic hips of 8 patients who underwent vascularized fibular grafting were compared with the 15 femoral head osteonecrotic hips of 13 patients

who underwent non-vascularized fibular grafting. All patients were operated between January 1999 and June 2008.

Each patient determined his/her treatment option after being informed of both surgical approaches by the doctors in our clinic. Only one patient whose left hip was grafted with a non-vascularized fibula due to an arterial occlusion in the left lower extremity did not receive the method requested.

Comparisons of the two groups according to the patients' age, etiology, average Harris hip and visual analog scale (VAS) scores were made and radiological evaluation was carried out using the Ficat staging system (Table 1).^[36]

Table 1. Radiological Ficat staging of the osteonecrosis of the femoral head.

Stage	Clinical outcome	Radiology
0	Pre-clinic	0
I	Pre-radiologic	+
II	Pre-collapse	+
A		+
		Generalized osteoporosis
		Sclerosis or cyst.
		Normal articular line.
		Normal shape of the femoral head
B		+
III	Collapse	++
		Crescent sign
		Flattening on the surface of dead bone.
		Articulation normal
IV	Osteoarthritis	+++
		Flattening on the femoral head. Articulation stenosis

For the operation, the patient was positioned in the lateral decubitus position for vascularized fibular grafting and the supine position for non-vascularized fibular grafting. During both surgical approaches, a duct was opened with cavitators of 12 to 20 mms, starting from the level of the proximal end of the trochanter minor under fluoroscopy to the femur proximal, progressing along the femur via a guard K-wire steered through the center of the osteonecrotic lesion in the femoral head. Thereafter, necrotic tissue was debrided using a reverse curette under fluoroscopy and the taken autogenous graft was applied with cancellous bone graft. Then, the proximal part of the fibula taken from the ipsilateral leg using the technique defined by Urbaniak et al.^[31] was inserted with the help of vascularized fibular impactor through the duct into the femoral head, 5 to 10 mm below the subchondral bone. In cases of non-vascularized fibular grafting, the graft taken with the

technique defined by Phemister,^[28] was similarly inserted with an impactor. A fixation was implemented with a K-wire of 1.5-2 mm after anastomosis in vascularized fibular grafting treatment, while fixation was not considered mandatory in cases of non-vascularized fibular grafting.

After operation, treatment with low molecular weight heparin was administered to all patients for 6 weeks. On the 3rd postoperative day, active and passive range of motion exercises for the hallux, ankle and knee were begun. Additionally, non-weight-bearing mobilization was implemented for the first 6 weeks. After the 6th week, partial weight mobilization was progressively started. Full weight-bearing mobilization was allowed in the 6th postoperative month. Radiological and clinical evaluations of the patients were carried out once every 3 months for the first year, bi-yearly for the following 3 years, and then annually.

Results

Among the 21 treated hips in 17 patients, the primary complaint was progressive pain in the inguinal region upon movement. The other 5 hips of 4 patients had limitation in hip range of motion with pain and limping complaints. According to preoperative evaluations of both groups, steroid usage was found as an etiologic factor causing osteonecrosis among 26 treated hips of 21 patients. Furthermore, there was no significant difference when evaluating the patients treated in both groups in their age, sex and preoperative Harris hip scores ($p>0.05$). According to the Ficat staging system for radiological evaluation, 4 hips were Grade 2A, 4 Grade 2B and 3 Grade 3 in the vascularized group. In the non-vascularized group, 8 hips were Grade 2A, 3 Grade 2B, 3 Grade 3 and one Grade 4. Postoperative average follow-up length was 22 (range: 12 to 57) months in the vascularized group and 42 (range: 16 to 114) months in the non-vascularized group (Table 2).

While analyzing preoperative and postoperative first year average Harris hip and VAS scores, it was found that the patients treated with vascularized fibular grafting had an average preoperative Harris hip score of 65.90 ± 7.08 and a mean VAS score of 7 ± 1.06 , where the mean postoperative Harris hip score was 83.09 ± 3.39 and average VAS score was 2.81 ± 0.60 . Patients treated with non-vascularized fibular grafting had an average preoperative Harris hip score of 68.40 ± 3.54 and a mean VAS score of 5.46 ± 0.99 , where average postoperative Harris hip

Table 2. Distribution of the factors in vascularized and non-vascularized fibular grafting.

Factors	Vascularized fibular grafting	Non-vascularized fibular grafting
Age	34 (30–40)	34 (17–66)
Male / Female	5 / 3	8 / 5
Average length of follow-up (months)	22 (12–57)	42 (16–114)
Average preoperative Harris hip score	65.90 ± 7.08	68.4 ± 3.54
Average preoperative VAS score	7 ± 1.06	5.46 ± 0.99
Etiology		
Steroid usage	7	7
Idiopathic	1	4
Alcohol abuse	0	2
Ficat staging (hip count)		
2A	4	8
2B	4	3
3	3	3
4	0	1

scores were 61.20 ± 4.26 and mean VAS scores were 4.20 ± 0.86 .

According to the average Harris hip and VAS scores of both groups in the first year, the results of the vascular fibular grafting group were significantly better ($p<0.05$) (Table 3). The one year follow-up Harris hip and VAS scores of the patients treated with vascular fibular grafting were significantly better ($p<0.05$) than the ones treated with non-vascular fibular grafting in Ficat Stage 2A, 2B and 3. There was also a significant difference ($p<0.05$) between preoperative and postoperative Harris hip and VAS scores of the patients treated with vascularized fibular grafting (Table 4).

No progress in osteonecrotic lesions, collapse or deterioration in the spherical structure of the femoral

Table 3. Analysis of preoperative and postoperative 1st year average Harris hip and VAS scores.

Factors	Vascularized fibular grafting	Non-vascularized fibular grafting
Preoperative Harris hip score	65.90 ± 7.08	68.40 ± 3.54
Postoperative 1st year Harris hip score	83.09 ± 3.39	61.20 ± 4.26
Preoperative VAS score	7 ± 1.06	5.46 ± 0.99
Postoperative 1st year VAS score	2.81 ± 0.60	4.20 ± 0.86

Table 4. Average Harris hip scores. (There is a significant difference ($p < 0.05$) among the groups, except Stage 4, based on Mann-Whitney U test).

Ficat staging	Preoperative		Postoperative 1st year	
	Vascularized	Non-vascularized	Vascularized	Non-vascularized
Stage 2A (n=11)	64.50 (60–66)	69.71 (68–72)	86.00 (84–88)	64.00 (62–68)
Stage 2B (n=7)	66.25 (60–83)	69.33 (68–72)	83.50 (82–84)	61.33 (60–62)
Stage 3 (n=7)	67.33 (62–72)	67.50 (62–72)	79.33 (76–82)	58.66 (52–66)
Stage 4 (n=1)	–	60.00	–	52.00
Total (n=26)	65.90 (60–83)	68.40 (60–72)	83.09 (76–88)	61.20 (52–68)

head was seen in the direct graphies and MRI controls at the first year follow-up (Figs. 1-4). Nonetheless, remission of osteonecrotic lesions was seen in patients with vascularized fibular grafting at

longer follow-ups (Figs. 5-7). No remission was seen in osteonecrotic lesions of the patients in which we administered non-vascularized fibular grafting (Figs. 8-10).



Fig. 1. Preoperative radiography and MRI views.

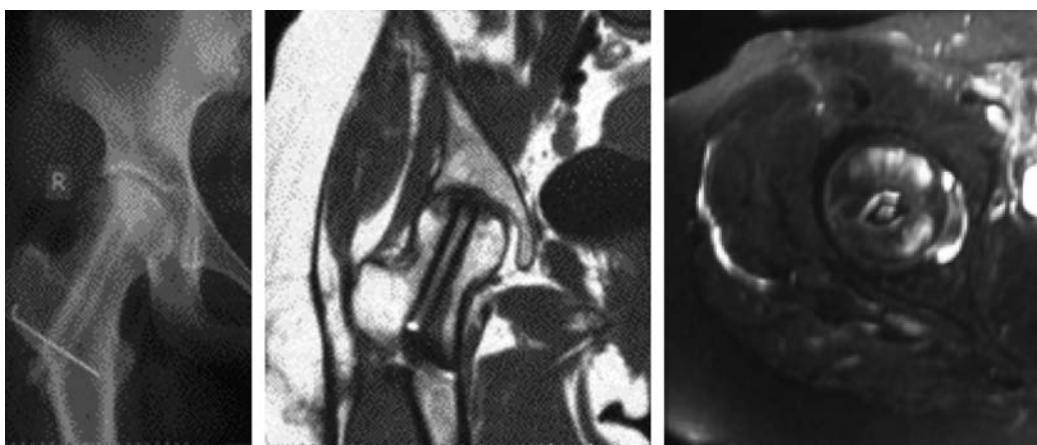


Fig. 2. Postoperative 12th month radiography and MRI views. In Figs. 1 and 2, no remission in the osteonecrotic lesion of the femoral head of the patient treated with vascularized fibular grafting and also at Ficat Stage 2A is seen.

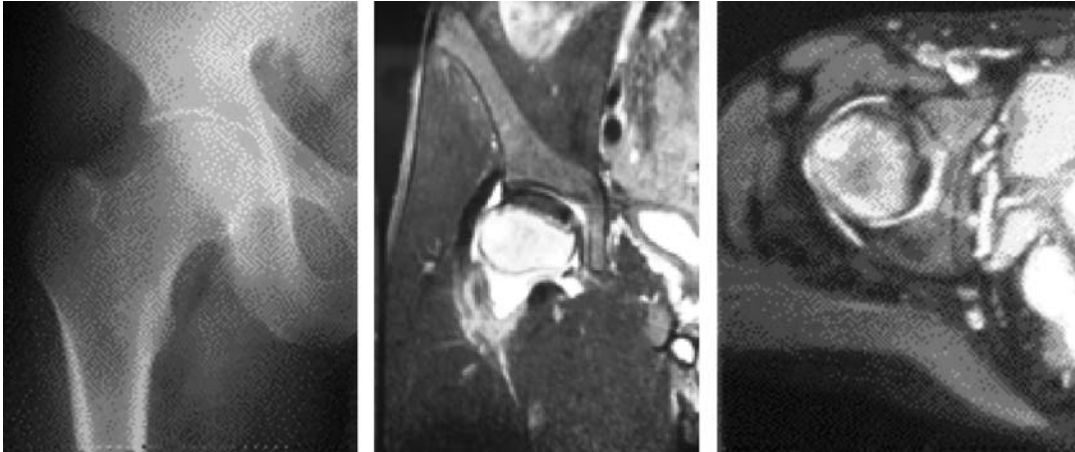


Fig. 3. Preoperative radiography and MRI views.

The average need of erythrocyte suspension was 4.09 units for the patients treated with vascularized fibular grafting, while it was 0.6 units for those treated with non-vascularized fibular grafting.

When we analyzed the complications of the patients in both groups, we only encountered compartment syndrome in a 31-year-old female patient at the donor site for the fibular graft. Thereupon, fasciotomy was performed and the fasciotomy wound was closed with a split-thickness skin graft. There was no neurovascular complication in the follow-up of this patient.

There were 2 exceptional patients treated with non-vascularized grafting at Ficat Stage 3, who needed a total hip replacement surgery at 36 and 60 months.

Discussion

Deterioration of nutrition in a part or the whole of the femoral head is considered as the main cause of avascular necrosis. It is most likely to occur in the 3rd and 4th decade of life and may proceed to hip joint breakdown.

In 70% to 80% of cases in which avascular necrosis of the femoral head is not treated radiological and clinical progress is inevitable. Femoral head collapse and degenerative changes in the joint can necessitate total hip replacement operation in a mean time of 2 years. Total hip replacement operations due to avascular necrosis of the femoral head cover 5% to 12% of all total hip replacement procedures.^[37,38]

In their 5 year ongoing follow-up study of 115 hips with avascular necrosis of the femoral head,

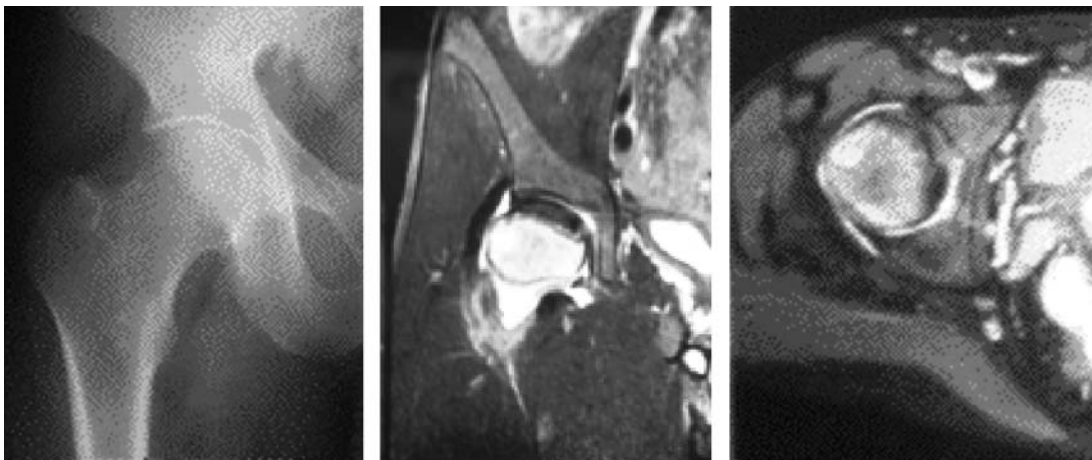


Fig. 4. Postoperative 12th month radiography and MRI views of the patient in Fig 3. No remission in Ficat Stage 2A osteonecrotic lesion of the femoral head was seen after non-vascularized fibular grafting.

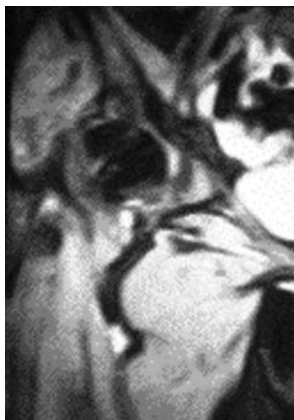


Fig. 5. Preoperative MRI view.

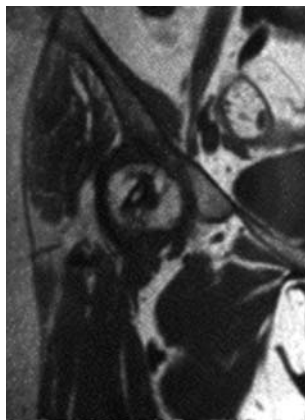


Fig. 6. MRI at the postoperative 24th month.

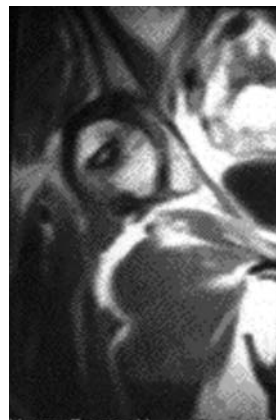


Fig. 7. MRI at the postoperative 48th month.

In Figs. 5, 6, and 7, there is a remission in Ficat Stage 3 osteonecrotic lesion of the femoral head of the patient treated with vascularized fibular grafting.

Ohzono et al. determined a 68% articular surface collapse rate.^[39] According to the prospective study of Stulberg et al., 20 out of 22 hips with avascular necrosis of the femoral head had bad clinical results.^[40]

In osteonecrosis of the femoral head, core-decompression^[19-21], electrostimulation^[22,23], transtrochanteric rotational osteotomies^[24], vascularized and non-vascularized fibular grafts^[25-30] or demineralized bone matrix and bone marrow are possible treatment options. In the advanced stages, however, total hip prosthesis may be the only solution.^[41-43]

A variety of success rates of non-vascularized fibular grafting in osteonecrosis of the femoral have been determined in different publications. Non-vas-

cularized fibular grafting was first defined by Phemister.^[28] One out of the 3 patients experienced collapse, and degenerative changes in the hip joint were encountered in the other 2 patients after 12 and a half months for one and after 7 and a half years for the other.

Marcus et al. analyzed the results of 11 patients with asymptomatic early stage osteonecrosis of the femoral head treated with Phemister type fibular grafting or tibia grafting.^[44] Results were clinically good for 7 patients, insufficient for 3, and bad for one. In their study, Dunn and Grow reported good results for 4 out of 23 patients, but revealed that treatment was not successful in advanced stages.^[45] Smith et al.^[30] followed up 56 hips for an average of



Fig. 8. Preoperative MRI view.



Fig. 9. MRI at the postoperative 12th month.

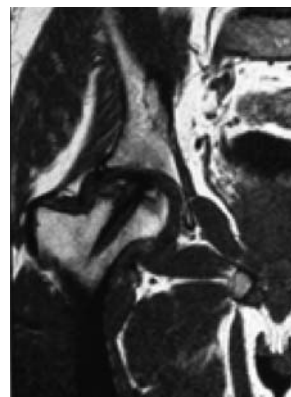


Fig. 10. MRI at the postoperative 24th month.

In Figs. 8, 9, and 10, there is a progress in Ficat Stage 2A osteonecrotic lesion of the femoral head of the patient treated with non-vascularized fibular grafting.

14 years. Thirteen hips did not receive arthroplasty and their clinical results were good for 8 and bad for the remaining 5. In a study of 52 hips with osteonecrosis of the femoral head, Nelson and Clark reported collapse in the femoral head of all hips.^[46]

In avascular necrosis of the femoral head, the first study on vascularized fibular grafting was published in 1979. The results of the first Turkish study were published by Yüçeturk et al. in 1996.^[47]

Many studies exist that address the successful results of the treatment of osteonecrosis of the femoral head with vascularized fibular grafting. In their study of 18 patients, followed-up for 5 years and over, Brunelli et al. obtained good and very good results in 84%.^[48] Yoo et al. found that 74 out of 81 hips they followed for a minimum 3 years had clinically good results and 72 hips managed radiological recovery.^[35] Urbaniak et al.^[31] treated and followed up for a minimum of 5 years 103 osteonecrotic hips with vascularized fibular grafting. The best results were obtained on small and medium sized pre-collapse lesions; 75% of those patients participated in a survey and 81% of them found the results satisfying. Total hip arthroplasty was performed afterwards on 2 out of 19 hips with pre-collapse lesions, 5 out of 23 hips with post-collapse lesions and 24 out of 62 hips with advanced stage lesions. Kane et al. reported that vascularized fibular grafting treatment provided significantly good results ($p < 0.05$) in the 40 patients at Ficat Stage 2 or 3 that they followed up for a minimum of 2 years.^[49] Sotereanos et al., in a study of 88 hips followed-up for a minimum of 3 years, obtained good or very good results in 58% Steinberg Stage 2C and 40% Steinberg Stage 3C patients.^[33]

Currently, there are two publications that compare vascularized and non-vascularized fibular grafting.^[50,51] The first is a retrospective cohort study of the vascularized fibular grafting operations (220 hips) and non-vascularized fibular grafting operations (123 hips) carried out by Plakseychuk et al., conducted in two institutions in different countries.^[50] In the study, the survival of Stage 1 and Stage 2 hips for 7 years was 86% after vascularized fibular grafting treatment and 30% after non-vascularized fibular grafting treatment. Better clinical and radiological results were also obtained if the vascularized fibular grafting treatment was implemented before the collapse of the femoral head. In another similar study by Kim et al.^[51], 23 hips of 19 patients receiving vascularized fibular grafting treatment

were compared with 23 hips of 19 patients receiving non-vascularized fibular grafting treatment. In this study, the patients treated with vascularized fibular grafting were retrospectively matched by etiology, stage and lesion size with a group treated with non-vascularized fibular grafting. For the total of 46 hips at Stage 2C, 3C and 4C, according to the classification of Steinberg et al., the average Harris hip scores of the vascularized fibular grafting treatment group were significantly better ($p < 0.05$) than those of the non-vascularized group. In the follow-ups, total hip prosthesis operations were necessary for 3 patients treated with vascularized fibular grafting and 5 patients treated with non-vascularized fibular grafting. There were significant differences ($p < 0.05$) between the two groups in terms of radiological progressions and incidence of collapse.

In our study, after one year the clinical results for the non-vascularized group were worse than the pre-operative state. Despite having no progress or remission of the avascular necrosis of the femoral head in either group in the early stages, this unexpected result made us think that this treatment approach would not be better in the long-term. There was no remission of osteonecrotic lesions of the femoral head on the 15 hips we treated with non-vascularized grafts. Degenerative changes, however, occurred on long-term follow-up of over 36 months in this group. Total hip prosthesis treatment had to be performed on 2 hips in the 36th and 60th months.

However, in the vascularized fibular grafting group, early clinical results were better than the pre-operative results. Remission of the osteonecrotic lesions of the femoral head was confirmed and no degenerative differences occurred on hips followed up for over 36 months in this group. Vascularized fibular grafting can stop the progression of the osteonecrosis of the femoral head in early stages, and prevent subchondral collapse in the late stage, thus extending the transition period to total hip prosthesis.^[52]

In conclusion, both early and late stage clinical and radiological results of vascularized fibular grafting is better than those of non-vascularized fibular grafting in the treatment of avascular necrosis of the femoral head and is recommended for patients with avascular necrosis of the femoral head who are under 50 years of age.^[31]

Conflicts of Interest: No conflicts declared.

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