The Role and Benefits of Free Vascularized Fibular Grafts in Avascular Necrosis of the Hip

Clinical Practice Today CME

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Learning Objectives

Upon completion, participants should be able to:

- Explain the goals, benefits, and risks of free vascularized fibular grafting
- Identify appropriate patient candidates for free vascularized fibular grafting

Introduction

Osteonecrosis of the femoral head (ONFH), also called avascular necrosis, is a debilitating bone disease that leads to destruction of the hip joint in people between the ages of 30 and 50 years.[1] ONFH affects approximately 10,000 to 20,000 new patients in the United States each year.[1] Common causes of ONFH include exposure to high-dose corticosteroids, trauma, and chronic alcohol consumption.[2-5] For nearly 25% of patients, however, ONFH is idiopathic.[3]

Introduction (cont.)

ONFH has been referred to as "the coronary disease of the hip" because it mimics the natural history of heart ischemia.[6] Following an initial ischemic injury to bone tissue, an impaired remodeling process contributes to progressive bone loss.[6] Without intervention, progression to femoral head collapse, pain, and hip dysfunction can be rapid.[4,6] Given that ONFH primarily affects younger individuals, a joint-preserving procedure is preferable to hip-replacement surgery.[4] This has the advantage of avoiding postoperative restrictions associated with joint-replacement surgery in this active patient population.[5] Therefore, treatment priorities for most patients with ONFH include[1,7]:

- Relieving pain by removing the necrotic bone
- Preserving or restoring the integrity of the femoral head
- Delaying the need for total hip arthroplasty (THA)

Introduction (cont.)

Multiple joint-preserving procedures have been used to treat ONFH, including core decompression, electrical stimulation, osteotomy, and nonvascularized and vascularized bone grafting.[1] Free vascularized fibular grafting (FVFG) is an effective option for salvaging the necrotic femoral head when performed prior to radiographic collapse in patients with ONFH.[4,8] For those with postcollapse ONFH, FVFG can still improve joint function while delaying the need for THA.[8,9]

FVFG Procedure

Urbaniak developed the FVFG procedure at Duke University Medical Center (DUMC) in 1979.[10] The FVFG procedure is typically performed by 2 surgeons who focus on the graft and donor sites, respectively.[9] During the procedure, the graft is harvested via fibular osteotomy with its associated vascular pedicle, the peroneal artery, and veins (Figure 1).[7,9]

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FIGURE 1. Fibula Harvest During FVFG Surgery

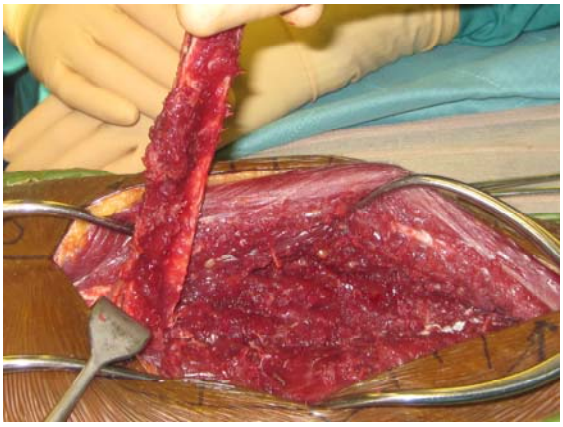
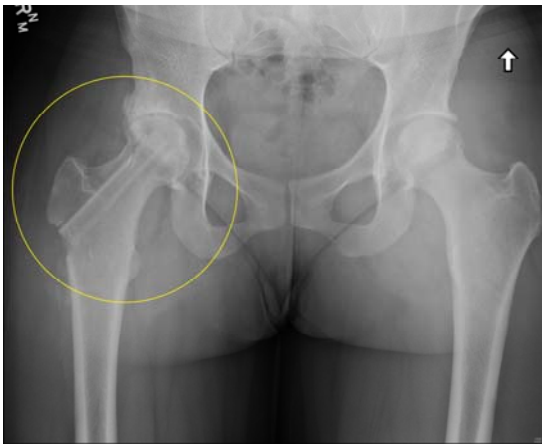


Image courtesy of Dr. Marc J. Richard, Duke University Medical Center.

FVFG Procedure (cont.)

By preserving the vascularity, the graft maintains its osteogenic potential.[11] The mid-portion of the fibula is harvested preserving the important proximal and distal tibiofibular ligaments. Simultaneously, the necrotic tissue is removed from the femoral head with the goal of interrupting the cycle of ischemia, intraosseous hypertension, and impaired remodeling.[5,7] This is performed by drilling from the lateral aspect of the hip into the center of the femoral head. The tract is progressively enlarged to accommodate the diameter of the harvested fibula (Figure 2).

FIGURE 2. Tract for Fibula Graft



Hip x-ray of a 28-year-old woman with posttraumatic ONFH from a previous hip dislocation. The tract created for the fibula graft before incorporation is circled.

Image courtesy of Dr. Marc J. Richard, Duke University Medical Center.

FVFG Procedure (cont.)

Through the same incision, the ascending branch of the lateral femoral circumflex vessels are identified and harvested for later anastomosis.[9] The graft is then placed into the defective area to support the femoral head, provide perfusion, and promote local revascularization.[1,5,7] Advances in microsurgical techniques have led to improved vessel anastomosis.[9] The vascularized bone graft is almost always successfully incorporated into the host bed, showing healing characteristics that are similar to those of a similar fracture.[1,12]

Candidates for FVFG

Ideal candidates for FVFG include patients younger than 35 years with symptomatic, precollapse ONFH.[9,13] However, the indications for FVFG are not rigid.[9] Multiple other factors such as disease stage, lesion size and location, disease etiology, and the presence of comorbidities influence the selection of appropriate intervention for patients with ONFH.[9]

Candidates for FVFG (cont.)

Disease Stage

Multiple classification systems have been developed to define disease stage in patients with ONFH.[14] The Steinberg classification system is considered particularly useful because it describes the severity of disease and the extent of involvement, both of which influence prognosis (Table 1).[14,15] Hips are first classified into stages 0 to VI based on radiologic findings; these stages follow the sequence of pathologic events that characterize the natural history of ONFH.

TABLE 1. Steinberg Classification of Osteonecrosis of the Adult Hip

Severity of Radiologic Findings		Extent of Involvement (Stages I-V)	
Stage		**Grade**	
0	Radiographs and bone scan/CT[a] or MRI are normal or nondiagnostic	A	< 15% of the femoral head involved
I	Radiographs are normal; MRI or bone scan/CT[a] is abnormal	B	15% to 30% of the femoral head involved
II	Radiographs demonstrate abnormalities consistent with osteonecrosis; head is round	C	> 30% of the femoral head involved
III	Radiographs reveal subchondral collapse producing a crescent sign		
IV	Flattening of the femoral head		
V	Narrowing of the joint space with or without acetabular involvement		
VI	Loss of joint space; advanced degenerative changes		

CT = computed tomography, MRI = magnetic resonance imaging.
[a]Bone and CT scans are used only when MRI is contraindicated.

Candidates for FVFG (cont.)

Disease Stage

After a stage is assigned, the extent of involvement is measured. For stages I through V, the extent of femoral head involvement is designated as A (< 15%), B (15% to 30%), or C (> 30%).[15] Typically, the extent of involvement is not described for patients with normal imaging (stage 0) or advanced degenerative changes (stage VI).

Candidates for FVFG (cont.)

Disease Stage (cont.)

The Harris Hip Score is a tool used for grading the severity of hip disabilities after hip surgery.[16] The tool encompasses 4 domains: function, absence of deformity, range of motion, and pain severity, including the effect of pain on activity level and the need for pain medication. The Harris Hip Score has a maximum of 100 points. Surgical results are considered excellent, good, fair, or poor based on the following postoperative scores[16]:

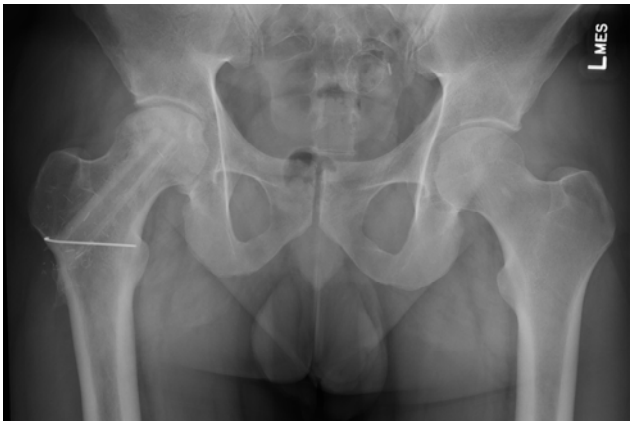
- Excellent: ≥ 90 points
- Good: 80 to 89 points
- Fair: 70 to 79 points
- Poor: < 70 points

Candidates for FVFG (cont.)

Disease Stage (cont.)

Surgical intervention in the earlier, precollapse stages of ONFH is associated with more favorable outcomes than treatment in postcollapse stages.[1] However, select patients with postcollapse ONFH can nonetheless benefit from the grafting procedure (Figure 3).[9]

FIGURE 3. Successful FVFG in Patient With Postcollapse ONFH



Hip x-ray of a 32-year-old man with mild postcollapse ONFH at 2 years post FVFG; graft has fully incorporated, and patient is doing well.

Image courtesy of Dr. Marc J. Richard, Duke University Medical Center.

Candidates for FVFG (cont.)

Disease Stage (cont.)

In a retrospective study of 224 hips with postcollapse, predegenerative ONFH, treatment with FVFG was associated with a 5-year joint survival rate of 64.5% and a substantial improvement in clinical status.[9] The mean Harris Hip Score increased from 54.5 before surgery to 81 points following FVFG.

Candidates for FVFG (cont.)

Size and Location of Necrosis

The size and location of the necrotic lesion also influences postsurgical outcomes.[13] In a retrospective study of 151 FVFG procedures in 135 patients with ONFH, smaller lesion size was associated with more favorable radiographic findings, higher Harris Hip Scores, and a lower likelihood of conversion to THA after a mean follow-up of 13.9 years (Table 2).[13]

Table 2. Outcomes More Than 10 Years Following FVFG According to Baseline Extent of Necrosis Involvement

	Steinberg Classification			
Endpoints	**A (n = 27)**	**B (n = 38)**	**C (n = 59)**	***P* Value**
Radiographically improved or unchanged	81.5%	57.9%	54.2%	.026
Harris Hip Score > 80	100%	78.9%	69.5%	.004
Conversion to THA	0%	78.9%	16.9%	.012

FVFG = free vascularized fibular grafts; THA = total hip arthroplasty.

Data derived from Yoo MC, Kim KI, Hahn CS, Parvizi J. Long-term followup of vascularized fibular grafting for femoral head necrosis. *Clin Orthop Relat Res*. 2008;466(5):1133-1140.

Candidates for FVFG (cont.)

Size and Location of Necrosis (cont.)

Regardless of lesion size, lateral lesions located on the weight-bearing surface of the acetabulum are associated with an increased likelihood of femoral head collapse.[13] In the study of 151 FVFG procedures, 12 of 13 graft failures occurred in hips with lateral lesions. By comparison, the graft survival rate was 100% for lesions involving the medial third of the weight-bearing dome of the acetabulum (*P* = .039).[13] Therefore, FVFG may have a limited role in the treatment of lateral lesions, particularly in cases of extensive necrotic involvement.

Candidates for FVFG (cont.)

Etiology of Necrosis

Many disease processes can culminate in ONFH.[3] In a series of 946 patients treated with FVFG at DUMC, the most common cause of osteonecrosis was chronic exposure to high-dose corticosteroids (n = 344).[3] Other leading etiologies included idiopathic necrosis (n = 221), trauma (n = 152), and chronic alcohol consumption (n = 148). In the remaining patients, ONFH was attributed to dysplasia, pregnancy, Perthes disease, infection, and miscellaneous causes.[3]

Candidates for FVFG (cont.)

Etiology of Necrosis (cont.)

Independent of disease stage, idiopathic osteonecrosis is associated with poor graft survival following FVFG.[4,13] Although the mechanistic relationship is unclear, idiopathic ONFH may result from underlying abnormalities (eg, intraosseous hypertension) that drive progressive changes to the femoral head despite treatment with FVFG.[4] Other etiologies also predict less-favorable postsurgical results.[9] In one analysis of FVFG for postcollapse ONFH, patients with idiopathic, alcohol-related, or posttraumatic osteonecrosis had significantly worse outcomes than those with osteonecrosis due to other causes, including steroid use (P = .017).[9] In contrast, patients with ONFH secondary to systemic lupus erythematosus generally do well with FVFG.[17]

Candidates for FVFG (cont.)

Patient Age

Some evidence indicates a greater likelihood of graft survival in younger patients, with optimal age thresholds in different FVFG studies ranging up to 35 or 40 years.[13,18] Other analyses, however, have found no independent association between patient age at the time of surgery and long-term graft survival or other postoperative outcomes.[4] Therefore, patient age is one of many factors that influence the appropriateness of FVFG.

Candidates for FVFG (cont.)

Patient Age (cont.)

Up to 9% of children and adolescents undergoing treatment for childhood malignancies develop ONFH as a complication of chemotherapy.[19] Due to delayed diagnosis in this patient population, pediatric patients tend to present with late-stage disease. In a series of pediatric patients with post-chemotherapy ONFH treated at DUMC, 16 of 18 patients (21 of 29 hips) showed evidence of flattening of the femoral head at the time of diagnosis.[19] As a strategy to delay THA, FVFG is often undertaken in pediatric patients with more-advanced ONFH features than those considered acceptable in older patients.[19]

By comparison, THA is the preferred intervention for patients older than 50 years with any degree of symptomatic ONFH and for those older than 40 years with advanced-stage disease, extensive involvement, or limited range of motion in the hip.[9]

Candidates for FVFG (cont.)

Comorbidities and Surgical History

Vascular integrity is critical to the success of vascularized bone grafting.[12] Therefore, patients with comorbidities such as peripheral vascular disease, deep venous thrombosis, or previous vascular damage are poor candidates for FVFG.[12] Patients with known vasculopathies, sickle cell disease, or clotting disorders that affect the microvascular portion of the procedure may not benefit from FVFG.[4,6,10] Additional exclusion criteria include hypoplasia or the absence of one or both of the anterior or posterior tibial arteries, a defect that occurs in 8% of the population; harvesting the vascularized fibular graft in these patients may compromise local circulation and lead to lower-limb ischemia.[12]

Candidates for FVFG (cont.)

Comorbidities and Surgical History (cont.)

Despite concerns over the potential loss of biomechanical integrity with prior core decompression, select patients with a history of core decompression may be appropriate candidates for FVFG.[20] In one retrospective analysis, previous core decompression did not significantly increase the rate of conversion to THA following FVFG.[20] After a mean follow-up of 48 months, 15 of 32 hips (47%) with a history of core decompression required conversion to THA, compared with 20 of 54 hips (37%) treated with FVFG alone (*P* = .57). The mean time to THA was similar with or without prior core decompression (96.9 months vs 73.1 months; *P* = .45). However, among patients with prior core decompression, Steinberg stage V disease (*P* = .037) and/or a history of corticosteroid use (*P* = .026) predicted significantly worse outcomes following FVFG.[20]

Benefits of FVFG

FVFG is associated with more favorable outcomes compared with other common surgical approaches to ONFH treatment.[1] In a recent meta-analysis, Fang and colleagues compared outcomes among patients with ONFH treated with FVFG (n = 740) or non-FVFG (n = 244) interventions.[1] The non-FVFG procedures included core decompression, nonvascularized fibular graft, and vascularized iliac graft. The analysis favored the use of FVFG to achieve a good to excellent clinical result (Harris Hip Score ≥ 80), prevent ONFH from progressing to collapse, and prevent or delay the need for THA (Table 3).

TABLE 3. Meta-Analysis of Outcomes Following FVFG or Non-FVFG Procedures in Patients With ONFH

Outcome	FVFG (n = 740)	Non-FVFG (n = 244)	OR	*P* Value
Good to excellent clinical result[a]	69.0%	25.0%	0.13	< .01
Conversion to THA	16.5%	42.6%	0.19	< .001
Femoral head collapse	16.7%	63.6%	0.09	< .05
Failure rate, Steinberg stage I-II disease	9.8%	40.2%	0.17	< .001
Failure rate, Steinberg stage II-III disease	16.5%	42.8%	0.17	< .001
Complications	23.8%	8.9%	3.44	.09

[a]Harris Hip Score ≥ 80 points.
FVFG = free vascularized fibular grafts; OR = odds ratio; THA = total hip arthroplasty.

Data derived from Fang T, Zhang EW, Sailes FC, McGuire RA, Lineaweaver WC, Zhang F. Vascularized fibular grafts in patients with avascular necrosis of femoral head: a systematic review and meta-analysis. *Arch Orthop Trauma Surg*. 2013;133(1):1-10.

Benefits of FVFG (cont.)

Although slightly more complications were observed in the FVFG cohort, the difference between complications in the FVFG and non-FVFG groups was not statistically significant (*P* = .09).[1]

Benefits of FVFG (cont.)

Successful FVFG enables patients to participate in high levels of physical activity, such as impact sports, for many years after surgery.[4] Eward and colleagues described favorable long-term outcomes following FVFG, including graft survivorship of at least 10 years in 75% of cases.[4] The retrospective study included data from 61 patients who underwent 65 FVFG procedures for precollapse ONFH at DUMC between 1979 and 1997. The mean age at surgery was 32.1 years (range, 12 to 40 years). Most of the etiologies of ONFH were steroid-induced (n = 27), idiopathic (n = 20), posttraumatic (n = 10), and chronic alcohol consumption (n = 5). Long-term function and activity level were measured with the modified Harris Hip Score, SF-12 physical component summary (PCS) and mental component summary (MCS), and an activity questionnaire. The minimum follow-up was 10.5 years.[4]

Benefits of FVFG (cont.)

At long-term follow-up, 39 hips (60%) had surviving grafts.[4] The mean graft survival time was 14.9 years (range, 10.5 to 26.1 years). Conversion to THA was required for 26 hips (40%) after a mean duration of 8.3 years. Pain and functional status were similar 10 years postoperatively in patients with surviving grafts and in those who converted to THA. However, patients with surviving grafts were significantly more likely to engage in impact sports or active events (Table 4).

TABLE 4. Activity Levels According to Graft Survival 10 Years After FVFG

Activity Levels	Hip Status at ≥ 10 Years: Surviving FVFG (n = 39)	Hip Status at ≥ 10 Years: Converted to THA (n = 26)	*P* Value
Impact sports[a] or active events[b]	64.0%	38.4%	.04
Mild[c] or moderate[d] activities only	30.7%	46.1%	.04

[a]Includes jogging, tennis, skiing, and ballet.
[b]Includes bicycling, golf, and bowling.
[c]Includes walking, limited housework, and limited shopping.
[d]Includes swimming, unlimited housework, and unlimited shopping.
THA = total hip arthroplasty; FVFG = free vascularized fibular grafts.

Data derived from Eward WC, Rineer CA, Urbaniak JR, Richard MJ, Ruch DS. The vascularized fibular graft in precollapse osteonecrosis: is long-term hip preservation possible? *Clin Orthop Relat Res*. 2012;470(10):2819-2826.

Benefits of FVFG (cont.)

In addition, patients with surviving grafts had higher mean SF-12 MCS scores at last follow-up than those who had undergone THA (54 vs 50; *P* = .018).[4]

Risks of FVFG

Procedural complications of FVFG are generally divided into 2 categories: those related to harvesting the fibular graft and those related to the hip reconstruction.[1,3] Gaskill and colleagues examined donor- and graft-site complication rates following FVFG procedures (N = 1,270) for ONFH in 946 consecutive patients treated at DUMC between 1990 and 2006.[3] At an average follow-up of 8.3 years, 215 complications were reported, representing a complication rate of 16.9%; these included 146 complications (11.5%) associated with the donor site and 69 complications (5.4%) at the graft site. The most common donor-site complications were great-toe flexion contracture and ankle pain/tenderness, observed in 37% and 36% of study participants, respectively; other less common complications included sensory complication (14%), superficial infection (7%), motor complication (5%), and deep infection (0.7%). The most common graft-site complications were pin migration and heterotopic ossification, experienced by 43% and 26% of subjects, respectively; other complications included femoral fracture (13%), deep venous thrombosis (6%), superficial infection (4%), deep infection (4%), hematoma (1%), and trochanteric bursitis (1%). More than two-thirds of the reported complications following FVFG were minor, asymptomatic, or transient. By comparison, 54 procedures (4.3%) were associated with a major complication that required chronic pain management or additional surgical intervention.[3]

Risks of FVFG (cont.)

The complication rates associated with FVFG have decreased substantially over the past 2 decades.[3] For instance, the risk of proximal femoral fracture at DUMC decreased from 2.5% in 1996 to 0.6% in 2009.[3] These changes have been attributed to increased institutional experience, more meticulous approaches to handling neurovascular structures, greater awareness of postsurgical complications, and more strictly enforced weight-bearing limitations following surgery.[3]

Functional outcomes among patients who convert to THA after failed FVFG are comparable to those of patients treated with primary THA.[2] Therefore, even in patients with graft failure, FVFG can delay the need for THA without compromising post-THA functional outcomes.[2]

Postsurgical Recovery

The average hospital stay for patients undergoing FVFG is 4 days.[9] Postoperative management includes antithrombotic therapy with intravenous dextran for 3 days followed by daily aspirin for 6 weeks. On postoperative day 2, all operative drains and catheters should be removed, and patients should begin physical therapy.[9]

Postsurgical Recovery (cont.)

Adherence to weight-bearing restrictions is critical for preventing early complications such as femoral head collapse and fracture.[9] In fact, results from a study performed at Duke demonstrate the importance of postoperative compliance.[21] The study compared FVFG outcomes between a group of 32 hips in healthcare professionals and a control group of 1,257 hips treated over the same time period. The healthcare professionals demonstrated a high degree of postoperative compliance and had a significantly lower rate of failure, defined as conversion to THA (6% vs 21%), leading the authors to highlight the relationship between outstanding postoperative compliance and favorable outcomes.[21]

Postsurgical Recovery (cont.)

For the first 6 weeks after surgery, patients should remain non–weight-bearing on the affected side. Progressive weight-bearing is permitted thereafter with the goal of reaching full weight-bearing by 6 months.[9] Physical therapy should also incorporate early motion and stretching of the toes and ankle to prevent great-toe flexion contracture and ankle pain/tenderness, the most common complications at the donor site.[3,9] Postoperative recovery should also be monitored with clinical and radiographic follow-up at 3 months, 6 months, and yearly thereafter.[9]

Postsurgical Recovery (cont.)

Continued corticosteroid exposure in patients treated for corticosteroid-induced ONFH is a potential cause for concern.[5] Corticosteroids adversely affect the femoral head in a dose-dependent manner, with up to 13% of patients treated with high-dose corticosteroids developing corticosteroid-induced ONFH. Patients treated for corticosteroid-induced ONFH often require continued low-dose corticosteroid therapy to manage an underlying autoimmune disorder such as systemic lupus erythematosus or rheumatoid arthritis.[5] In a recent retrospective analysis of 44 patients (78 hips) with corticosteroid-induced ONFH, FVFG appeared to be a viable option for patients treated with postoperative maintenance corticosteroids at a mean dose equivalent of prednisolone 5.8 mg/day.[5] Compared with baseline, FVFG significantly improved mean Harris Hip Scores (70.9 vs 84.0; $P < .05$) and SF-36 physical and mental component scores ($P < .05$), as well as improved radiographic findings in 63% of hips. During the mean follow-up of 5.6 years, only 7 hips (9%) required conversion to THA. According to the study authors, these results suggest that the benefits of revascularization and new bone growth achieved through FVFG exceed the potential harmful effects of low-dose maintenance corticosteroid therapy.[5]

Conclusion

FVFG is an effective option for improving hip function, relieving pain, and delaying the need for THA for select patients with ONFH. The choice to undertake FVFG should be made after weighing the potential benefits and limitations of treatment given each patient's age, etiology of ONFH, size and location of the necrotic lesion, and the presence of comorbidities. Given the importance of weight-bearing restrictions for up to 6 months as a part of postsurgical recovery, the patient's ability to adhere to postoperative instructions may also be an important decision-making factor.

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