Vascularized Fibular Grafts for Avascular Necrosis After Slipped Capital Femoral Epiphysis

Is Hip Preservation Possible?

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Received: 6 July 2012 / Accepted: 26 December 2012 / Published online: 16 January 2013
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Abstract

Background Avascular necrosis (AVN) of the femoral head is a potential complication in patients with slipped capital femoral epiphysis (SCFE), radiographically occurring in 3–60%. This may lead to early hip fusion or hip arthroplasty. Free vascularized fibular grafting (FVFG) may provide a reasonable means to preserve the femoral head.

Questions/Purposes We asked: (1) What percentage of patients with AVN after SCFE treated with FVFG underwent subsequent THA or hip fusion and what was the lifespan of the FVFG? (2) Did the graft survival rate of FVFG for AVN after SCFE coincide with historically reported rates of FVFG for idiopathic AVN? And (3) did hip function improve after FVFG?

Methods We retrospectively reviewed 52 patients who underwent FVFG for SCFE. We calculated the longevity of the graft and factors associated with graft survival. Harris hip scores (HHS) were recorded pre- and postoperatively. Minimum followup was 1 month (median, 19 months; range, 1–136 months).

Results Five of the 52 patients (10%) underwent conversion to THA (four) or hip fusion (one). Mean age was greater in these patients than in those not requiring further procedures: 16 versus 13 years. Median graft survival time before arthroplasty/fusion was 12 years (range, 2–16 years) while it is currently 8 years (range, 2–16 years) in patients not undergoing subsequent procedures. HHSs improved 35 points on average (38 points preoperatively to 73 points postoperatively).

Conclusions In patients undergoing FVFG for AVN secondary to SCFE, 90% have maintained their native hips for 8 years with improved hip function, similar to other published reports of FVFG. Further followup is needed of patients currently retaining their FVFGs as to eventual conversion to THA or fusion.

Level of Evidence Level IV, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Slipped capital femoral epiphysis (SCFE) is a condition in which the proximal femoral metaphysis displaces secondary to a diseased hypertrophic zone of the proximal femoral physis while the epiphysis retains a normal position in the acetabulum. The incidence in the United States is roughly 10 in 100,000. This can occur as an acute event, or more typically, over a period of months. The typical proximal metaphysis displacement leaves the epiphysis in a position posterior and inferior to the metaphysis, resulting in abnormal hip mechanics and pain. Common complications include osteoarthritis and femoroacetabular impingement. SCFE has been classified in two ways: acute versus chronic and stable versus unstable. An acute slip is defined by onset

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Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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of symptoms less than 3 weeks before the time of presentation. An unstable slip has been defined clinically (child's inability to bear weight through the affected extremity) and radiographically (no signs of joint effusion or metaphyseal remodeling on ultrasound). The standard of care in treatment of SCFE remains in situ pinning, yet in the acute or unstable slip, it is not uncommon for an interruption to the blood supply of the femoral head to occur, resulting in consequent avascular necrosis (AVN) [5, 7–9]. Sankar et al. [14] reported AVN occurred in 10–60% of acute slips. AVN can lead to debilitating hip pain and the need for a hip fusion or THA, which is an unattractive option in a pediatric population due to the relatively short lifespan of the implant compared to that of the patient [8, 11, 12, 14].

The free vascularized fibular graft (FVFG) was developed to serve as a biologic support to a devascularized femoral head [16, 17]. This procedure uses the patient's autologous fibula with its accompanying vessels, providing a fresh blood supply and bony support to the healing femoral head (Fig. 1). While steroid-induced osteonecrosis has been the most prevalent indication for FVFG, data support its use in other pediatric conditions, such as trauma, pyarthrosis, and malignancy [3, 15]. Overall, FVFG for AVN provides a near 75% rate of hip preservation for at least 10 years postoperatively (range, 10–26 years) [4]. However, it is unclear whether patients with AVN after SCFE who undergo FVFG have similar rates of hip preservation over this same followup period.

Therefore, we reviewed our experience with this operation for the indication of AVN after an SCFE and answered the following questions: (1) What percentage of patients with AVN after SCFE treated with FVFG underwent subsequent THA or hip fusion and what was the lifespan of the FVFG before the subsequent procedure?

Fig. 1 A schematic diagram illustrates FVFG with anastomosis to the lateral femoral circumflex artery (LFCA) vessels and the graft stabilized with a K-wire.

(2) Did the rate of graft survival of FVFG for AVN after SCFE coincide with historically reported rates of graft survival for FVFG for idiopathic AVN? And (3) was there a clinical improvement in hip function after FVFG?

Patients and Methods

We retrospectively reviewed our prospective database of 55 patients referred to our institution for consideration of a FVFG after SCFE between 1980 and 2010. All patients' AVN was directly related to their SCFE. The indications for FVFG in these patients were (1) symptomatic AVN, (2) age 50 years or younger, and (3) presence of an intact fibula in a well-perfused leg. The contraindications were (1) age older than 50 years, (2) hip arthrosis, and (3) bilateral lower-extremity vasculopathy based on symptoms or absence of distal pulses. No patients in the study group were on chronic steroid therapy, had a prior hip pyarthrosis, or had a history of malignancy. Three patients were excluded secondary to inadequate followup data, leaving 52 patients for analysis. There were 33 males and 19 females, with 38 left hips and 15 right hips (one case of bilateral FVFGs). Two hips had Ficat Stage III AVN [13], 42 hips had Stage IV AVN, and eight hips had Stage V AVN. The average age of all patients undergoing FVFG after SCFE was 14 years (range, 10–26 years) and the average time from diagnosis of SCFE to FVFG was 13 months (range, 4–36 months). The minimum followup was 1 month (median, 19 months; range, 1–136 months). No patients were recalled specifically for this study; all data were obtained from medical records and radiographs. We had prior approval of our institutional review board.

The FVFG procedure has been described in detail elsewhere [1]. All procedures were performed by one of four surgeons, each of whom performed the procedure in a similar fashion. In brief, a surgical team extraperiosteally exposed and removed approximately 10–15 cm of the central portion of the patient's ipsilateral fibula with its accompanying vessels. Another team exposed the proximal femur and isolated the lateral femoral circumflex artery and vein. A core decompression of the patient's AVN lesion was undertaken, and local autogenous bone graft was then tamped into the lesion. The fibula was then placed into the femoral neck such that it abutted the previous devascularized lesion. The fibular artery and vein were then anastomosed to the lateral femoral circumflex artery and vein, and the graft was stabilized with a K-wire.

Postoperatively, patients were typically kept as inpatients for 3–4 days for pain management and anticoagulation with aspirin and dipyridamole. An epidural catheter was the primary means of postoperative analgesia. They were evaluated by physical therapists on the first postoperative day and

typically discharged home on the third or fourth postoperative day. The first followup occurred in the sixth postoperative week. During the first 6 weeks postoperatively, the patients remained nonweightbearing on their operative side but performed daily ROM exercises for their hip, knee, and ankle. For patients who received bilateral grafts, the second procedure was performed at least 6 weeks after the first side.

One of the four operating surgeons performed clinical evaluation at each postoperative visit, which normally occurred at 3, 6, 12, 18, and 24 months postoperatively. In some patients, travel distance necessitated portions of followup by a local orthopaedic surgeon. In this situation, a followup form was provided to the orthopaedic surgeon performing the followup. This form, along with recent radiographs, was forwarded to Duke University for review by one of the four operating surgeons. We assessed function and activity level pre- and postoperatively using the modified Harris hip score (HHS) [6].

Graft survival was calculated via the Kaplan–Meier method using conversion to THA or hip fusion as an end point. We compared mean pre- and postoperative HHSs

using the paired t-test. All analyses were performed using SAS® software (SAS Institute Inc, Cary, NC, USA).

Results

Of the 52 study patients, five (10%) had undergone conversion to THA (four) or hip fusion (one). Four of these patients had Stage IV AVN and one patient had Stage V AVN. The mean age was greater ($p = 0.021$) in patients undergoing further procedures than in those not undergoing further procedures: 16 versus 13 years. The median time of graft survival before arthroplasty/fusion was 12 years (range, 2–16 years). The median age of graft survival in those patients who have not undergone subsequent procedures is currently 8 years (range, 2–16 years).

With conversion to THA or fusion as an end point, the survival rate of the FVFG was 75% at 10 years (Fig. 2).

HHSs improved 35 points on average (38 points preoperatively to 73 points at last followup) (Table 1). This was driven by increases in functional scores with minimal increases in hip ROM.

Fig. 2 A Kaplan–Meier survival curve shows 90% survival at nearly 10 years postoperatively.

Months	Survival	Lower CI pointwise	Upper CI pointwise	Lower CI band	Upper CI band
26	0.97959	0.86383	0.99710	0.60926	0.99914
102	0.94331	0.78083	0.98633	0.54463	0.99441
144	0.86470	0.58380	0.96150	0.29669	0.98276
185	0.64853	0.17931	0.89662	0.01740	0.95477
192	0.43235	0.06343	0.77495	0.00308	0.88553

Table 1. Pre- and postoperative Harris hip scores

Variable	Preoperative	Postoperative	p value
Total hip score (points)	38.3 ± 32.1	73.2 ± 22.8	0.001
Individual items (points)			
Pain	24.8 ± 16.2	35.1 ± 14.3	0.003
Crutch	2.8 ± 4.8	8.5 ± 4.2	< 0.001
Limp	3.9 ± 4.5	7.2 ± 3.9	0.001
Distance	4.1 ± 4.7	7.2 ± 3.9	< 0.001
Sit	5.1 ± 3.8	8.1 ± 4.2	0.9353
Shoe	1.0 ± 1.6	4.9 ± 3.1	< 0.001
Stairs	0.8 ± 1.6	2.6 ± 1.6	0.001
Bus	0.2 ± 0.4	0.6 ± 0.5	< 0.001
ROM (°)			
Flexion	82.8 ± 35.4	89.7 ± 33.9	0.9440
Abduction	29.1 ± 18.2	37.7 ± 12.2	0.1346
Adduction	16.1 ± 10.2	21.7 ± 10.9	0.1690
External rotation	28.3 ± 26.3	38.1 ± 10.7	0.0955
Internal rotation	9.0 ± 18.0	17.3 ± 11.8	0.3466

Values are expressed as mean ± SD.

Discussion

AVN of the femoral head after a SCFE can be a debilitating complication with poor outcomes. FVFG for AVN reportedly has a 75% survival rate at 10 years in preserving the patient's native hip in other conditions [4]. However, it is unclear whether FVFG for AVN after SCFE would have similar survival. We therefore raised the following questions: (1) What percentage of patients with AVN after SCFE treated with FVFG underwent subsequent THA or hip fusion and what was the lifespan of the FVFG before the subsequent procedure? (2) Did the rate of graft survival of FVFG for AVN after SCFE coincide with historically reported rates of graft survival for FVFG for idiopathic AVN? And (3) was there a clinical improvement in hip function after FVFG?

We acknowledge several limitations to our study. First, our study lacks a control group treated either nonoperatively or with another femoral head-preserving procedure. Our referral population did not include many patients with small Ficat Stage I lesions and it is not our intention to imply we would recommend FVFG for such lesions. Outcomes of AVN up to 31 years after SCFE have been reported by Krahn et al. [10], in which nine of 24 patients had reconstructive hip surgery and those who did not undergo a procedure had radiographic changes of hip arthrosis. Second, due to lack of information maintained in

our institution's electronic medical record database, it is unknown how many of these patients with SCFE had stable or unstable slips. However, we do not believe outcomes after FVFG for AVN would be substantially different if the inciting event was a stable versus unstable slip. Third, we acknowledge a large number of FVFGs are performed at our institution annually and therefore our results may not be applicable if performed in a less highly specialized setting. Fourth, our study lacks long-term radiographic analysis, which may imply a certain percentage of these hips have gone on to radiographic failure in terms of subsequent hip arthrosis or clinical failure in terms of THA or fusion.

FVFG has reported rates of overall survivorship in the range of 61–96% [2–4, 15–17]. In another study recently performed at our institution looking at 65 hips undergoing FVFG for multiple etiologies contributing to osteonecrosis of the femoral head, 40% of patients went on to THA at an average of 8.3 years after undergoing FVFG [4]. Our outcomes, although specifically for AVN after SCFE, compare favorably, with close to 10% of patients going on to THA or fusion at an average of 10.8 years postoperatively.

Eward et al. [4] showed in their series of 65 hips undergoing FVFG that 75% of patients had graft survival at 10.5 years and 60% of patients at 14.9 years. Although we do not have long-term outcomes (> 10 years postoperatively) to report on, approximately 90% of patients undergoing FVFG for AVN after SCFE have retained their native hip at an average of 8.4 years. In other pediatric conditions, we have reported a survival rate approaching 85% at 4 years [3].

Idiopathic AVN is associated with a higher rate of disease progression compared to other etiologies, such as trauma or steroid use [4]. Sixty percent of hips that undergo FVFG for idiopathic AVN reportedly undergo conversion to THA in less than 10 years after the index procedure [4]. Although we do not propose a direct comparison of patient demographics between these studies and ours, FVFG for AVN after SCFE in this study does show a substantially lower rate of conversion to THA or fusion than historically reported rates for FVFG after idiopathic AVN.

We conclude FVFG for AVN after SCFE is associated with slightly higher rates of graft survival (approximately 90%) and hip function (HHS, 73 points) (case example, Fig. 3) at a median of 12 years postoperatively than prior published findings (Table 2). In those patients who underwent conversion to THA or fusion, the mean duration of graft survival was 10 years. Further followup is needed of current patients who remain with their FVFG as to eventual conversion to THA or fusion.

Fig. 3A–C (A) A 13-year-old boy developed AVN 1 year after in situ screw fixation for SCFE. (B) A radiograph shows the hip after FVFG. (C) A radiograph taken 8 years after FVFG shows the hip has minimal collapse, a well-shaped femoral head, and no joint destruction.

Table 2. Comparison of our study with those in the literature

Study	Intervention	Number of patients	Mean followup (years)	Number of patients needing further procedures	Time to further procedures (months)	Clinical outcome
Dean et al. [3]	FVFG	50	4.3	8	38	HHS increased from 55 to 90
Ko et al. [9]	Trapdoor procedure	13	4.5	4	6–36	9 Good 2 Fair 2 Failure
Gomez et al. [5]	Articulated hip distraction	28	4.7	5	Not listed	78% of patients had decrease in pain
Current study	FVFG	52	1.5	5	144	HHS increased from 38 to 73

FVFG = free vascularized fibular graft; HHS = Harris hip score.

Acknowledgments We thank Jennifer Friend, Clinical Research Coordinator, for her contributions to data collection and review and Cynthia L. Green, PhD, for help with the statistical analysis.

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