Medial Femoral Condyle Free Flap Reconstruction of Complex Foot and Ankle Pathology

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Introduction

Standard bone grafting techniques require a well vascularized recipient bed to maintain osteocyte viability and allow for successful osseous union. Due to the large articular surfaces of the navicular and talus, their blood supply is relatively tenuous and they are subjected to significant stress during ambulation. This combination predisposes them to arthrosis, AVN, and nonunion which can present a challenging problem for foot and ankle surgeons and often leaves arthrodesis as the only possible option.[1] If revision arthrodesis is required, this further exacerbates the problem by resulting in greater bone loss, soft tissue compromise, and less consistent fusion rates.[2] The medial femoral condyle (MFC) free flap enables transfer of vascularized periosteum with viable corticocancellous bone to promote osseous union in bone defects that are unlikely to achieve successful union with standard bone grafting techniques.[3,4]

Methods

A retrospective review of medial femoral condyle free flaps performed for foot and ankle reconstruction at a single institution between 2013 and 2019 was completed following institutional review board approval. MFC reconstruction was indicated for patients who presented with complex hindfoot pathology that required recruitment of additional vascularized bone in order to optimize the potential for osseous healing and successful orthopedic treatment. Patient demographics, operative details, and postoperative outcomes were obtained for analysis. Preoperative and postoperative American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scores were calculated for functional outcomes comparison.[5] Osseous union was assessed with serial radiographic or computed tomography, with complete union defined as date of imaging study when complete union noted within the official radiology report.

The MFC flap was harvested under tourniquet control as described previously.[4] Following completion of the procedure, all patients were placed in a posterior splint with leg elevation and strict non-weightbearing. Flap monitoring was most commonly performed using an external Doppler probe over the pedicle in 28 cases, however, an implantable Cook Doppler probe was used in two cases (one arterial, one venous).

Results

Over the six-year study period, 30 MFC free flap reconstructions were performed in 28 patients for complex hindfoot pathology. A history of trauma was the most common etiology (73%) followed by idiopathic avascular necrosis (17%). The majority of patients had undergone previous hindfoot surgery (67%) with an average of 3.1 prior operations (range 1-10). Most of these patients (17 out of 20) ultimately failed at least one arthrodesis procedure prior to referral. Avascular necrosis of one or more hindfoot bones was present in 83% of patients with the navicular (n = 13) and talus (n = 12) most commonly affected. Arthritis (76%) and osseous nonunion (73%) were also common upon presentation.

Orthopedic interventions performed concomitantly with MFC flap reconstruction are listed in Table 1 along with the respective bone flap insertion sites. The majority of hindfoot procedures involved arthrodesis of at least one joint (n = 24, 80%), with tibiotalocalcaneal (n = 11) and talonavicular (n = 7) fusions the most common. K-wire fixation of the MFC flap was utilized most frequently (n = 17), followed by press-fit (n = 5), K-wire and screw (n = 4), screw (n = 2), plate and screw (n= =), and plate only (n = 1).

The ipsilateral knee was the MFC donor site in all but two cases. The mean osseous volume was 10.3 cm^3 (range 1.7-18.4cm^3). Bone-only free flaps were utilized in 14 cases. A chimeric skin paddle was carried with 15 of the flaps (50%) and a segment of vastus medialis muscle was incorporated in one case for soft tissue coverage in the setting of inadequate perforators. The descending geniculate artery supplied the flap in the majority of cases (n = 26), however, in 4 cases the MFC pedicle arose from the superior condylar branch of the medial geniculate artery. The anterior tibial vessels were the most common recipient vessels (n = 25) followed by the posterior tibial vessels in 5 cases. End-to-end arterial anastomoses were performed in 23 cases and one or two venae comitantes were utilized for venous outflow.

Table 1. Operative Details of MFC Hindfoot Procedures

Orthopedic Procedure	n	MFC Insertion Site	n	Bone Flap Fixation	Bone Flap Volume, cm^3 mean (range)
Tibiotalaocalcaneal Arthrodesis	11	Tibiotalar joint	9	K-wire (n = 8); Screw (n = 1)	12.2 (6.5-18.4)
		Sinus Tarsi	2	K-wire (n = 2)	
Talonavicular Arthrodesis	7	Talonavicular Joint	7	K-wire (n = 4); K-wire and screw (n = 1); Plate and screw (n = 1); Press-fit (n = 1)	7.8 (2-16)
ORIF Navicular Nonunion	4	Navicular Waist	4	K-wire and screw (n = 3); K-wire (n = 1)	3.8 (1.7-6)
Triple Arthrodesis	4	Talonavicular Joint	2	Press-fit (n = 2)	14.4 (10.5-17.5)
		Navicular (excised)	2	K-wire (n = 1); Plate (n = 1)	
Subtalar Arthrodesis	2	Sinus Tarsi	2	K-wire (n = 1); Screw (n = 1)	10.5 (9-12)
Tibial Saucerization	2	Tibial metaphysis	2	Press-fit (n = 2)	9.8 (9-10.5)

Average postoperative length of hospital stay was 4.9 days (range 3-11 days). Flap complications occurred in 6 patients. There were 3 partial skin paddle losses and 2 total skin paddle failures, however, the underlying bone flap was noted to be viable in all cases during operative debridement. One patient required a takeback for venous thrombosis related to pedicle kinking on postoperative day 1 with successful flap salvage. One patient developed a donor site seroma that required operative drainage.

Out of 30 patients, 27 had adequate clinical and imaging follow up to be included for outcomes analysis with a mean follow up duration of 15.5 months (range 4-33 months). Average time to partial weight bearing was 49 ± 22 days (range 26-100 days) and to full weight bearing was 99 ± 39 days (range 57-208 days).

Primary osseous union was initially achieved in 20 patients (74%) by an average of 217 ± 114 days (range 110-475 days). Of the six patients who developed an interface nonunion, 5 of them underwent revision arthrodesis with bone grafting and achieved subsequent union. Ultimately, complete osseous union was achieved in 25 patients (93%) with an average time to union of 271 ± 165 days (range 110-628 days). One patient developed a chronic nonunion and refused additional surgery, while the second patient is ambulating with an asymptomatic partial union.

Risk factors for the development of nonunion following MFC reconstruction were evaluated. MFC nonunion was associated with a BMI greater than 35 ($p = 0.011$) and a history of prior failed arthrodesis ($p = 0.042$). Orthopedic procedure, bone flap insertion site, fixation method, and flap volume were not associated with subsequent nonunion.

Fifteen patients required additional procedures subsequent to their MFC flap reconstruction (6 soft tissue, 9 orthopedic). Flap soft tissue debulking was performed in 4 patients, and 2 required operative debridement for delayed wound healing at the recipient site. Revision arthrodesis for nonunion was required in 5 patients. Two patients underwent pin removal, one patient had tibial screw removal for rod dynamization, and one required excision of heterotopic bone.

In order to measure functional outcomes, AOFAS Hindfoot Scores were calculated for patients. Mean preoperative scores were 60 ± 13 (range 37-83) out of 100. When evaluated at least 6 months postoperatively, average AOFAS scores had increased significantly to 73 ± 17 (range 36-95) ($p = 0.001$).

Discussion

In the setting of compromised vascular supply to the bones of the foot and ankle related to trauma, surgery, or other mechanisms the risk of avascular necrosis (AVN) and nonunion may be as high as 30-40%.[2] Within this challenging cohort of patients, our series of vascularized bone transfer with the medial femoral condyle free flap ultimately achieved osseous union in 93% of patients. Initial interface nonunion after MFC flap reconstruction was associated with BMI over 35 and a history of failed arthrodesis. Functional status was also significantly improved after MFC reconstruction with AOFAS Hindfoot Scores increasing from 60 preoperatively to 73 in the postoperative period ($p = 0.001$).

This study is limited by the retrospective nature, lack of a control group, and heterogeneity of orthopedic procedures performed. The vascularized bone flap insertion site varied according to the area of avascular bone and required tailoring to each specific defect in terms of flap size and fixation method. Despite limitations, however, we were able to demonstrate significant improvement in functional outcomes and achieve relatively high fusion rates in a challenging patient population.

References

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