

Free Microvascular Transfer of the Proximal Fibular Epiphysis to Reconstruct the Lateral Malleolus in a Pediatric Patient

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Background	A five-year-old female with no significant past medical history presented with a two-month history of right leg pain without an antecedent traumatic event. On exam, she had a mass over the lateral malleolus on the right. She underwent neoadjuvant chemotherapy after a bone biopsy revealed an Ewing sarcoma. She subsequently underwent resection of her sarcoma. The lateral malleolus was reconstructed using an ipsilateral free proximal fibula based on the peroneal artery. Debate remains over the ideal vascular pedicle to allow for the continued growth of the epiphyseal plate following free flap or pedicled reconstruction using the proximal fibular head.
Summary	The patient has minor hindfoot varus and dynamic supination with gait. She is ambulating independently and is using a lateral heel post to assist with foot position. She has minimal pain and deformity of the ankle. MRI and plain radiographs were taken at 33 months postoperatively and demonstrated a stable position of the graft with evidence of physseal/epiphyseal remodeling.
Conclusion	Reconstruction of an epiphyseal plate lends a unique challenge to surgeons. Transfer of a vascularized epiphyseal plate leads to optimal long-term results due to the continued growth of the graft. This report is unique because the peroneal artery is used with 33 months of follow-up. Overall, the results and function of the patient are acceptable.
Key Words	fibula; epiphyseal; transfer; lateral; malleolus

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Case Description

A five-year-old female with no significant past medical history presented with a two-month history of right leg pain without an antecedent traumatic event. On exam, she had a mass over the lateral malleolus on the right. MRI was obtained, which demonstrated a destructive bone lesion measuring 3 × 2 × 14 cm of the distal fibula. She underwent neoadjuvant chemotherapy after a bone biopsy revealed an Ewing sarcoma. Following chemotherapy, her sarcoma was reimaged and found to have decreased in size to 2 × 1 × 11 cm. She was subsequently taken to the operating room and underwent resection of her sarcoma, followed by ipsilateral free vascular transfer of the proximal fibula and epiphyseal plate using the peroneal artery as a pedicle. She is currently 33 months postoperative and is weight-bearing as tolerated to the right lower extremity. She has minimal pain or deformity of the ankle. She has minor hindfoot varus and dynamic supination with gait. She is ambulating independently and is using a lateral heel post to assist with foot position (Figure 1). MRI and plain radiographs were taken at 33 months postoperatively and demonstrated the stable position of the graft with evidence of physeal/epiphyseal remodeling (Figure 2).

Figure 1. Postoperative Photo of Wound. Published With Permission



Figure 2. Postoperative Radiographs at 33 Months. Published with Permission



Images demonstrate good alignment of flap and stable ankle and physeal/epiphyseal remodeling

Discussion

All relevant articles were included, and relevant citations were cross-referenced within each article in the literature review. Four relevant articles were identified (Table 1 outlines a current review of the literature). All articles describe using the proximal fibular head, including the epiphyseal plate, to reconstruct the ipsilateral distal fibular defect. Two articles discuss the free microvascular transfer, and two describe a pedicled reverse-flow flap. One of the reverse flow flaps required a venous interposition graft.¹ One of the flaps was based on the peroneal artery, and three were based on the anterior tibial artery. All four case reports have good long-term follow-up with no evidence of graft loss or ankle instability. Of note, two of the children requiring lateral malleolus reconstruction had injuries related to lawnmower accidents, one from a car accident and one due to sarcoma. Furthermore, one patient was 13 years of age at the time of reconstruction, and the author postulates that skeletal growth was complete at the time of reconstruction.¹

Pediatric patients with bony defects present a unique challenge to the reconstructive surgeon. The loss of an epiphyseal plate is ideally reconstructed with a new plate that will grow with the patient and prevent further joint instability and deformity. Both Bibbo and Rajacic present children who initially did not undergo reconstruction of the lateral malleolus but subsequently presented with complaints of ankle instability and increasing valgus deformity.^{2,3} A stable ankle reconstruction that can provide longitudinal limb growth must be accomplished while minimizing donor site morbidity. We chose to use the ipsilateral fibular head to prevent donor site morbidity on her healthy leg in our patient. All case reports in our literature review also used ipsilateral proximal fibula.

Table 1. Postoperative Radiographs at 33 Months. Published with Permission

Author	Mechanism of injury	Age*	Flap Type	Pedicle	Follow Up	Proximal Fixation	Distal Fixation
Nebojsa, R	Car accident/ crush injury	8	Reverse flow Pedicled with vein graft	anterior tibial artery	4 years with normal growth and ankle stability	intra-osseous wiring and free bone graft between tibia and fibula	slit tendon of peroneus brevis passed through holed drilled in fibula and sutured
Bibbo, C	Riding lawnmower accident	6	free flap	anterior tibial artery	2 years with continued growth ankle stability	2.5-mm locking plate securing fibula to fibula	biceps tendon used to recreate calcanea-fibular ligament
Sales de Gauzy, J	osteogenic sarcoma resection	13	reverse flow pedicled	anterior tibial	2.5 years with no pain and full ankle function	fibular osteotomy and screw fixation to tibia	lateral collateral ligament and biceps tendon sutured to, trans epiphy- seal screw placed
Concan- non, M.J.	lawnmower accident	4.5	free flap	peroneal	5 years with normal growth and ankle stability	pinned with exten- sion of fibula into tibial IM canal	placed adjacent to talus

*age in years at time of surgery

Debate remains over the ideal pedicle to use when performing an epiphyseal transfer.⁴ Papadopulos and Innocenti have previously described their series of patients with fibular head microvascular transfer used to reconstruct the growing wrist and forearm.^{5,6} Both of these authors have postulated that when the fibular pedicle is based on the peroneal artery, there is an increased risk for the early fusion of the growth plate and the risk of insufficient blood supply. Of the four previous case reports relevant to our patient, one surgical team used the peroneal artery, and three used the anterior tibial artery. One of the anterior tibial artery patients had reached a state of relative skeletal maturity.¹ Both pedicles were described to have good outcomes without progressive ankle instability or mention of limb length discrepancy. We believe that more research into ideal pedicle selection will help to guide further surgeons in making this critical decision.

We chose to fixate the proximal fibular shaft to the lateral tibia to secure our graft and allow for the appropriate direction of fibular growth. This was performed by creating a small hemicortical osteotomy with a burr hole into the tibia. Synostosis was created, and we then used a 3.5 mm positional screw that held the fibula secure. The lateral ligaments of the turned-down proximal fibula were used to re-create the lateral malleolus using FiberWire™. A wide variety of proximal and distal graft fixation methods were used in the reviewed literature and are summarized in Table 1.

One limitation of our case report is that our follow-up period of 33 months is still a relatively short time. We may not be able to detect early growth plate fusion and subsequent limb length discrepancy at the time of follow-up. The four papers listed in our case report have varying follow-up times based on the patient's age and time-to-publication. Sales de Gauzy presented a 13-year-old boy in whom he postulated that evaluating growth was not possible due to his patient having already reached skeletal maturity. He placed a trans-epiphyseal screw for distal fixation of the graft. Piper et al. reported that although limb length discrepancy is common in pediatric patients undergoing fibular reconstruction, only 14% require reoperation.⁷ They postulate that this indicates the pediatric population's ability to adapt, compensate, and eventually achieve independent ambulation.

Conclusion

Taylor et al. reported the first successful microvascular free fibula transfer in humans in 1975.⁸ Microvascular free fibula transfer has since been described as a workhorse in bony reconstruction following tumor resection.⁹⁻¹¹ In the pediatric population, continued longitudinal growth of the transferred fibular epiphysis makes the proximal head of the fibula an ideal choice for the reconstruction of bones requiring continued growth with the patient. It has also been documented that transfer of the epiphysis may lead to active remodeling of the osteoarticular surface.^{5,12,13} These

authors also postulate that the anterior tibial artery is the blood supply to the epiphysis and that basing the flap off of the peroneal artery results in early closure of the growth plate, limited long-term growth, and possible necrosis of the graft.⁶ Growing patients with loss of the distal fibula have demonstrated progressive ankle instability and valgus deformity when left untreated.^{2,3,14} Only a few case reports of the proximal fibular head are used to reconstruct the lateral malleolus in the pediatric or adult population. We believe the proximal fibular head is an ideal graft for lateral mortis reconstruction in the pediatric population, and further studies into the ideal pedicle need to be completed.

Lessons Learned

The proximal fibular head is an ideal graft for reconstruction of the lateral malleolus in the growing patient. More data regarding pedicle selection and graft fixation techniques will further help surgeons refine this reconstructive technique.

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