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Case Report

Bidirectional Limb Salvage and Its Impact on Residual Limb Survivorship: Is a Partial Calcanectomy in Ambulatory Midfoot Amputees Worthwhile?

Craig J. Verdin [1,*], Nicole K. Cates [2], Holly D. Shan [3], Karen K. Evans [1], Christopher E. Attinger [1], John S. Steinberg [1] and Jayson N. Atves [1]

[1] Department of Plastic and Reconstructive Surgery, MedStar Georgetown University Hospital, Washington, DC 20007, USA; karen.k.evans@medstar.net (K.K.E.); christopher.attinger@medstar.net (C.E.A.); john.steinberg@medstar.net (J.S.S.); jayson.atves@medstar.net (J.N.A.)
[2] School of Medicine, University of Maryland, Baltimore, MD 21201, USA
[3] Department of Plastic Surgery, Georgetown University School of Medicine, Washington, DC 20007, USA; hs730@georgetown.edu
* Correspondence: cverdin@gradymem.org

Abstract

Partial calcanectomies and midfoot amputation are commonly used functional limb salvaging interventions; however, it is well documented that they independently result in global biomechanical disruption of diabetic foot, further placing the residual limb at risk for limb loss. We retrospectively identified and reviewed 9 ambulatory midfoot amputees (10 feet) who developed heel osteomyelitis, whom were treated with an ipsilateral partial calcanectomy to determine whether the combined anterior and posterior interventions result in additive dysfunction that impacts function or places the residual pedal construct at risk for limb loss.

Keywords: amputation; calcanectomy; limb salvage; ambulation

1. Introduction

Midfoot amputation is a commonly used limb salvage intervention that effectively treats infection, ischemia, and non-healing ulcerations of the forefoot; however, it is well documented that they result in global biomechanical disruption of diabetic foot, further placing the residual limb at risk for limb loss [1–5]. As a result, transfer lesions are common and the creation of a short lever arm for ambulation places patients at increased risk of heel ulceration and increases the rate of development of heel ulceration after midfoot amputation, which can be as high as 47% [6–8]. In the setting of calcaneal osteomyelitis, which has the largest amount of morbidity and even mortality associated with its development, the partial calcanectomy (PC) is a well-documented intervention; however, not much is known on whether or not a PC in an already biomechanically compromised and shortened amputated foot increases the risk of limb loss [9–17].

Given the biomechanical changes that are independently associated with both midfoot amputation and partial calcanectomy, we seek to determine if the additive and cumulative biomechanical disruption seen in bidirectional limb salvage results in increased rates of failure, loss of ambulatory status, and complications, short and long term.

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2. What We Observed

After Institutional Review Board (IRB) approval, we identified nine patients with 10 feet who had Current Procedural Terminology (CPT) code 28120 (partial excision of calcaneus) and 28805 (transmetatarsal amputation) or 28800 (midtarsal amputation) at Georgetown University Hospital. Average age and body mass index (BMI) was 53 years (range, 30 to 66 years) and 28.3 kg/m^2 (range, 21.64 to 39.44). Eight patients (88.9%) had diabetes mellitus, five (55.6%) had chronic kidney disease, seven (77.8%) had peripheral arterial disease, and two (22.2%) were active smokers. The average Charlson index, which predicts 10-year survival of patients with multiple comorbidities, was 5.4 (range, 2–10). With respect to level of midfoot amputation, 2/10 feet (20%) were amputated at the Chopart level, 3/10 (30%) at the Lisfranc level, and 5/10 (50%) were at the transmetatarsal level. With respect to laboratory data, the average hemoglobin A1c at the time of the most recent intervention (calcanectomy) was 8.2%.

All patients underwent subsequent ipsilateral partial calcanectomy, consisting of traditional calcanectomy or vertical contour calcanectomy (Figure 1), with an average of 24.9 months between index midfoot amputation and partial calcanectomy. All complications and failures were attributed to the poor healing of the heel wound as opposed to failure of the midfoot amputation stump. The only minor complication requiring intervention was dehiscence in two (20%) feet and secondary below-knee amputation (BKA) was performed in two limbs (20%). When evaluating the patients who failed bidirectional interventions, Patients #5 and #9, the average time until BKA was 210 days, average hemoglobin A1c was 6.1%, and average BMI of 7.0 kg/m^2. Demographically, both had diabetes and peripheral vascular disease. Patient #5 had a previous history of chronic heart failure and was not a smoker. Patient #9 was a current smoker but did not demonstrate any other serious comorbidities beyond treated hypertension.



Figure 1. Plain film radiographic examples of midfoot amputation (transmetatarsal) with partial calcanectomy (traditional calcanectomy (**A**) and vertical contour calcanectomy (**B**)).

At a mean follow-up of 19.5 months (594 days) after the calcanectomy was performed, three (33%) of the previously ambulatory patients were no longer ambulatory at the most recent follow-up, with all three patients who experienced loss of ambulation being patients who underwent bidirectional limb salvage. Of the 66.7% (6/9) of patients who maintained the ability to ambulate, 33.3% (2/6) were BKA patients who ambulated with the assistance of a prosthetic and 66.7% (4/6) were patients who underwent bidirectional limb salvage. Patient demographics are outlined in Table 1.

Table 1. Summary of patient demographics.

Patient	Gender	Age at Time of Midfoot Amputation (Years)	BMI (kg/m^2)	Level of Amputation	Laterality	Time to Calcanectomy (Days)	Adjunct Procedures	Ambulatory Postoperatively?	Proximal Amputation?	Time to BKA (Days)	F/u Duration (Days)	Diabetic?	Hemoglobin A1C (%)	PVD	CKD	CCI
1	Male	62	21.64	TMA	Left	108	None	Yes	No	N/A	1713	No	8.5	Yes	No	5
1	-	-	-	TMA	Right	53	None	-	No	N/A	-	-	-	Yes	No	-
2	Male	66	27.72	TMA	Left	36	None	Yes	No	N/A	83	Yes	7.2	Yes	Yes	7
3	Male	39	23.6	TMA	Right	2105	None	Yes	No	N/A	442	Yes	12.7	Yes	Yes	3
4	Male	62	23.53	TMA	Right	98	None	No	No	N/A	355	Yes	6.5	Yes	No	10
5	Female	39	39.44	Lisfranc	Left	3044	Tendoachilles lengthening	Yes	Yes	162	187	Yes	4.1	No	Yes	5
6	Female	30	39.08	Lisfranc	Right	889	Tibialis anterior tendon lengthening, Achilles tenotomy, peroneus brevis tendon transfer	No	No	N/A	946	Yes	12.4	No	No	2
7	Male	60	24.43	Lisfranc	Right	480	Achilles tenotomy	Yes	No	N/A	529	Yes	7.5	Yes	Yes	6
8	Male	63	29.16	Chopart	Right	194	Achilles tenotomy	Yes	No	N/A	360	Yes	6.4	Yes	Yes	7
9	Male	56	25.83	Chopart	Left	493	Achilles tenotomy	Yes	Yes	258	731	Yes	8.1	Yes	No	4

BKA: below knee amputation; BMI: body mass index; CCI: Charlson Comorbidity Index; CKD: chronic kidney disease; DM II: diabetes mellitus; F/u: follow-up; N/A: not applicable; PVD: peripheral vascular disease; TMA: transmetatarsal amputation.

3. Discussion

In our observation, we posit that bidirectional limb salvage in the bidirectionally threatened limb is certainly possible and worthwhile in the properly selected patient. Unfortunately, when the interventions are performed on the same foot, there does appear to be some consequences with roughly 42.9% (3/7) of our successful cases of bidirectional limb salvage losing their ability to independently ambulate in the postoperative course. Despite the unfortunate loss of ambulation in patients, our findings are comparable to the isolated midfoot amputation and calcanectomy literature with respect to ambulation rates and limb salvage rates [15,18].

In a study in 367 patients by Ordaz et al., the authors found that 56.8% of transmetatarsal amputees were ambulatory after an average of 181 days [18]. In a study by Cates et al., 69% of partial calcanectomy patients were ambulatory at the 1-year mark [15]. The partial calcanectomy and the transmetatarsal amputation are considered to be the most gait preserving amputation levels, which was demonstrated in an article by Brown et al. [19]. In our observation, 3/4 (75%) transmetatarsal, 2/2 (100%) Lisfranc, and 2/3 (67%) of Chopart amputations were ambulatory in the acute postoperative course but one Lisfranc and one Chopart went on to receive a below knee amputation after 162 and 258 days for recurrent infection of heel, respectively. After a follow-up of 19.5 months, there was a 100% (5/5) salvage rate with transmetatarsal, 66% (2/3) salvage rate with Lisfranc, and 50% (1/2) for Chopart amputations. Given the well-documented biomechanical disruption that is associated with Lisfranc and even more so with Chopart amputation, an argument can be made that significant reduction in the pedal lever arm length along with associated loss of vital soft tissue structures places the calcaneal intervention at increased risk for failure due to the relocation to and concentration of plantar pressures on the heel; however, our conclusions warrant further investigation. In our observation, none of the patients developed an equinovarus deformity; however, this may be as a result of the prophylactic release of problematic posterior and medial structures when indicated.

The heel soft tissue envelope is notoriously durable when intact; however, when the envelope is compromised, healing is often difficult despite being perfused by multiple inflow vessels [20]. In our observation, five patients had no three-vessel runoff, two had two-vessel runoff, and one had three-vessel runoff. Unfortunately, none of the five patients with zero-vessel runoff had vessels that were amenable to revascularization but were deemed to have sufficient collateralization. Not surprisingly, the two patients who failed had zero-vessel runoff, which placed them at increased risk for failure. While not always possible, when possible, Cates et al. concluded that the most important vessel for calcanectomy success was the posterior tibial artery; therefore, this artery should be targeted when possible [21].

In the end, with an 80% limb salvage rate and 57.1% rate of ambulation, we propose that bidirectional limb salvage is most appropriate in patients that seek to maintain or improve ambulation and are candidates for the procedure. While the argument can be made that a below the knee amputation is the ideal level of amputation for a patient who seeks to maintain functionality, the previously mentioned study by Ordaz et al. showed that only 30.9% of patients who underwent a below knee amputation maintained gait preservation at an average follow-up of 315 days—making the bidirectional approach certainly worthwhile [18].

While we believe our observations are valuable, our evaluations do have their own inherent limitations. While the development of heel ulcerations after midfoot amputation is relatively common, performing a partial calcanectomy in a midfoot amputee is not ubiquitous, further making large-scale studies and comparisons difficult. Furthermore, it is not clear whether bidirectional limb salvage is superior to the alternative, which is a BKA.

While the ambulatory rates of isolated TMAs and calcanectomies are acceptable, it does appear that the addictive effect of the procedures do have their own inherent consequences.

4. Conclusions

In conclusion, the findings of this interesting observation reveal an acceptable rate of limb survivorship and preservation of ambulatory status in patients who underwent bidirectional limb salvage, which is relatively comparable to the independent midfoot amputation and partial calcanectomy literature; however, these findings should raise concern regarding expectations of salvage and ambulation in patients with midfoot amputation requiring subsequent partial calcanectomy all in an effort to reduce morbidity and mortality in this at-risk patient population.

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