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Case Reports and Series

The Vertical Contour Calcanectomy, an Alternative Approach to Surgical Heel Ulcers: A Case Series

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ABSTRACT

Heel ulcers have a significant impact on lower-extremity morbidity and confer high risk of major amputations. Treating these ulcers is difficult because of poor tissue coverage and the bony os calcis, often leading to proximal amputation. This case series shows the vertical contour calcanectomy (VCC) as a surgical alternative in functional limb salvage. Sixteen feet (14 patients) with recalcitrant heel wounds who underwent VCC were identified. The minimum follow-up time for inclusion was 1 year. Body mass index, diabetes, renal disease, peripheral vascular disease, lymphedema/venous insufficiency, smoking status, Charcot, amputation, vascular intervention, wound recurrence, reoperation rate, and ambulatory status were evaluated. The average follow-up time was 27.1 months (range 13.5 to 51.1). At 1 year of follow-up, 56% of heel wounds (9 of 16) treated with the VCC remained closed. An average of 1.44 subsequent surgeries were required per patient. Baseline or improved ambulatory status was achieved in 69% of patients (9 of 14) at 1-year follow up and 100% of patients (8 of 8) at 2-year follow up. The overall rate of major amputation was 19%. The long-term ambulatory status of patients treated with the VCC shows promise. The VCC should be considered as an alternative, reliable, surgical limb salvage tool for heel ulcerations.

Plantar heel ulcers are notoriously difficult to treat because of plantar pressures, prevalence of infection/osteomyelitis, tenuous vascular supply, and neuropathy in patients with high-risk medical comorbidities (1). Increased posterior pressures in bed-bound patients and increased plantar pressure during ambulation decrease wound healing ability, especially in patients with complex comorbidities (2). In the lower extremity, the heel is the most common location for pressure ulceration, and the second most common in the body (3). The effects of heel ulcerations on patient function are devastating. Diabetic foot ulcerations are the number 1 cause of below-the-knee amputation (BKA) from nontraumatic causes (4). Decubitus heel ulcerations increase mortality by 2.81 times for in-hospital patients (5). With an expanding population of obese patients, the difficulty in treating heel ulcers and the rate of heel ulcerations is increasing (6).

Heel ulcerations are further complicated by the presence of infection and osteomyelitis. Calcaneal osteomyelitis accounts for 7% to 8% of all osteomyelitis in adults (7). In cases of necrotizing soft tissue infection and sepsis, a proximal amputation is often required (1,8). Osteomyelitis in the calcaneus can increase the odds of a major amputation by 15 times, although extension of the ulcer to the calcaneus does not definitively indicate osteomyelitis (1,9). Eradication of the infection is indicated; however, a dead space can result from aggressive curettage of the calcaneus and can increase the recurrence of the infection (10).

With the prevalence of peripheral artery disease in this patient population, regardless of other compounding ulcer etiology, vascular intervention is often necessary. Shah et al (11) showed limb salvage rates of 86% at 5 years for diabetic patients with heel ulcerations treated with revascularization. Although vascular intervention can address large vessel disease, microvascular disease often present in patients with advanced diabetes is exceedingly difficult to treat. The effects of microvascular disease are pronounced in wound healing and peripheral sensation (12). This cascade of microvascular disease, and in turn, the sensory deficits, can lead to higher plantar pressures and shear forces, which result in ulceration (13).

To address a lack of evidence-based options between partial calcanectomy and major lower-extremity amputation, the vertical contour calcanectomy (VCC) was introduced (2). With the ultimate goal of functional limb salvage, the VCC provides a functional alternative to the traditional partial calcanectomy while avoiding or delaying major lower-extremity amputation in cases of heel ulcerations. The VCC is a modification of the partial calcanectomy that provides a consistent

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approach and reproducibility. The long-term outcomes of the VCC as a treatment for recalcitrant heel ulcerations with and without osteomyelitis are unknown at present.

The primary aim of the present study is to analyze the outcomes of patients who underwent a VCC procedure because of plantar heel ulceration with a minimum of 1-year follow up. The outcomes included number of postoperative surgeries, major lower-extremity amputation, 30-day readmission rates (related to the lower extremity only), mortality, and ambulatory status. The VCC, in theory, has the ability to maintain ambulation in patients that would have otherwise lost a limb to amputation.

Patients and Methods

The study was approved by Georgetown University Hospital Institutional Review Board. We performed a comprehensive chart and radiographic review of all patients who underwent a VCC from March 2014 to July 2016 using Current Procedural Terminology code 28120 (partial saucerization of bone, calcaneus), querying the records of 3 of the authors (C.E.A., P.J.K., and J.S.S.). All radiographs were evaluated by physicians to confirm the VCC technique was used. The patients in the cohort were treated over a 2.4-year period (year to year) by the Georgetown Limb Salvage team for acute or chronic heel wounds. Patients were treated on an outpatient basis or admitted to the Georgetown Limb Salvage team for treatment of lower-extremity infection and/or ischemic changes. Patients had surgical debridement before VCC based on need to eradicate infection determined by clinical signs of infection and postlavage cultures. VCC and closure were performed after eradication of infection, and vascular optimization was ensured. Patients were excluded from the cohort if they were <18 years of age, had <1 year postoperative follow-up, were treated with nonsurgical management, or did not have a VCC performed. With the above exclusion criteria, 14 patients (16 limbs) were included in the cohort.

Demographic data collection included age, body mass index, diabetes mellitus, Charcot neuroarthropathy, renal disease (including chronic kidney disease and end-stage renal disease), peripheral vascular disease, transplant history, coronary artery disease, cancer history, human immunodeficiency virus history, autoimmune disease history, and smoking history (current or former). Additionally, data were collected on whether the patient preoperatively had an angiography and angiography intervention, whether the patient had preoperative osteomyelitis (based on bone biopsy), the length of time in days with heel ulceration before VCC, and contralateral amputation. Operative data included number of surgical debridements before VCC, whether primary closure was performed, and number of surgeries to closure after VCC. Postoperative data on number of surgeries post-VCC, whether major lower-extremity amputation (defined as BKA, knee disarticulation, or above-the-knee amputation [AKA]) was performed, 30-day readmission rate (related to lower extremity only), and mortality. Data on ambulation status was collected and categorized into full weightbearing, partial weightbearing, and non-weightbearing before surgery and after surgery at 1, 2, and 3 years.

For statistical analysis, descriptive statistics were used to describe study subjects. Continuous variables were described by means, mode, and range (minimum–maximum).

Results

Overall demographic data is presented in Table 1. There were 14 patients and 16 limbs in the cohort. The mean age at the time of VCC was 63.8 years (range 51 to 86; mode 59). The mean body mass index was 34 kg/m^2 (range 23 to 53; mode 26). The prevalence of diabetes was 85.7% (12); Charcot neuroarthropathy, 28.6% (4); renal disease (chronic kidney disease and end-stage renal disease), 28.6% (4); peripheral vascular disease, 50% (7); transplant history, 14.3% (2); coronary artery disease, 14.3% (2); cancer, 28.6% (4); human immunodeficiency virus, 7.1% (1); autoimmune, 0% (0); lymphatic/venous disease, 35.7% (5); and smoking (current or former), 50% (7).

Outcomes categorized into preoperative considerations, operative course, and postoperative outcomes are seen in Table 2. Preoperative osteomyelitis diagnosed by bone biopsy was prevalent in 50% (8 of 16 limbs). Patients had a preoperative ulceration for an average of 292.1 days (range 10 to 1247; mode 129). Contralateral amputation (BKA or AKA) was present preoperatively in 7.1% (1). Preoperative angiography was performed in 68.8% (11 of 16 limbs), with intervention performed in 31.3% (5 of 16 limbs). Before the VCC surgery, surgical debridement was performed in a range of 1 to 4 surgeries. Before VCC, a single surgery was performed in 12.5% (2 of 16 limbs), 2 surgeries in 56.3% (9 of 16 limbs), 3 surgeries in 25% (4 of 16 limbs), and 4 surgeries in 6.3% (1 of 16 limbs). Primary closure post-VCC was performed in 50% (8 of 16 limbs). The number of surgeries after VCC ranged from 0 to 3. No postoperative surgeries occurred in 50% (8 of 16 limbs), 1 postoperative surgery in 12.5% (2 of 16 limbs), 2 postoperative surgeries in 18.8% (3 of 16 limbs), and 3 postoperative surgeries in 12.5% (2 of 16 limbs). At 1 year of follow-up, 56% of heel wounds (9 of 16 limbs) treated with the VCC remained closed. Major lower-extremity amputation (BKA/AKA) occurred in 18.8% (3 of 16 limbs), and 30-day readmission rate (related to lower extremity only) was 14.3% (2 patients). There was a mortality rate of 21.4% (3 patients).

Ambulation status categorized into full weightbearing, partial weightbearing, and non-weightbearing is seen in Table 3. Preoperatively, 50% of patients (7) were full weightbearing, 28.6% (4) were partial weightbearing, and 21.4% (3) were non-weightbearing. At 1 year postoperatively, 42.9% (6) were full weightbearing, 28.6% (4) were partial weightbearing, and 28.6% (4) were non-weightbearing. At 2 years postoperatively, 75% (6 of 8) were full weightbearing, 25% (2 of 8) were partial weightbearing, and 0% were non-weightbearing. At 3 years postoperatively, 75% (3 of 4) were full weightbearing, 25% (1 of 4) was partial weightbearing, and 0% were non-weightbearing.

Table 1
Demographics of patients who underwent vertical contour calcanectomy (N = 14)

	Percent (n)	Mean (range)	Mode
Age (years)		63.8 (51 to 86)	59
Body mass index (kg/m^2)		34 (23 to 53)	26
Diabetes mellitus	85.7 (12)		
Charcot neuroarthropathy	28.6 (4)		
Renal disease (CKD/ESRD)	28.6 (4)		
PVD	50 (7)		
Transplant	14.3 (2)		
CAD	14.3 (2)		
Cancer	28.6 (4)		
HIV	7.1 (1)		
Autoimmune	0 (0)		
Lymphatic/venous disease	35.7 (5)		
Smoker (current or former)	50 (7)		

Abbreviations: CAD, coronary artery disease; CKD, chronic kidney disease; ESRD, end-stage renal disease; HIV, human immunodeficiency virus; PVD, peripheral vascular disease.

Table 2
Operative considerations and outcomes of 16 lower extremities undergoing VCC (N = 14 patients)

Factor	Percent (n/N)	Mean (range)
Preoperative considerations		
Osteomyelitis	50 (8/16)	
Ulcer prior to VCC surgery (days)		292.1 (10 to 1247) (mode 129)
Contralateral amputation	7.1 (1/14)	
Angiography	68.8 (11/16)	
Angiography intervention	31.3 (5/16)	
Operative course		
Primary closure	50 (8/16)	
Surgeries before closure of VCC		
One	12.5 (2/16)	
Two	56.3 (9/16)	
Three	25 (4/16)	
Four	6.3 (1/16)	
Postoperative outcomes		
Number of postoperative surgeries		
Zero	50 (8/16)	
One	12.5 (2/16)	
Two	18.8 (3/16)	
Three	12.5 (2/16)	
Major lower-extremity amputation	18.8 (3/16)	
30-day readmission rate (related to lower extremity only)	14.3 (2/14)	
Mortality	21.4 (3/14)	

Abbreviation: VCC, vertical contour calcanectomy.

Table 3
Demographics of patients who underwent vertical contour calcanectomy (N = 16)

Ambulatory Status	Preoperative (n = 14)	Postoperative		
		1 Year (n = 14)	2 Years (n = 8)	3 Years (n = 4)
Full weightbearing	50 (7)	42.9 (6)	75 (6)	75 (3)
Partial weightbearing	28.6 (4)	28.6 (4)	25 (2)	25 (1)
Non-weightbearing	21.4 (3)	28.6 (4)	0 (0)	0 (0)

Data are % (n).

Discussion

Patients with plantar heel ulcerations pose a particular challenge to clinicians and are at a high risk for major lower-extremity amputations. With the ultimate treatment goals of eradication of infection, soft tissue coverage, biomechanical stability, and function limb salvage, there are nonsurgical and surgical interventions available. Nonsurgical options include offloading, local wound care, antibiotics, and medical comorbidity management (1,14). Hyperbaric oxygen can be used as adjunctive treatment in wound care to accelerate the rate of healing because of possible physiological angiogenesis at the site of the ulcer (15). Nonsurgical intervention does not typically address the true etiology of heel ulceration, including poor vascular supply, infection, biomechanical instability, and soft tissue coverage.

Surgical interventions include soft tissue work consisting of debridements, skin grafts, and/or flap reconstruction; osseous intervention including partial and total calcanectomies; vascular intervention; and major limb amputations (BKA/AKA) (16). In cases of large soft tissue defects, as a result of infection or skin breakdown from pressure or biomechanical instability, methods of soft tissue coverage can be used, including negative pressure wound therapy, local rotational flaps, or free flaps (17). Flap reconstruction is a useful tool for heel ulceration; however, it has some relative contraindications. In a study by Oh et al (18), the rate of flap loss rate was increased by an odds ratio of 17 in the patients with a history of angioplasty and increased by an odds ratio of 10 in patients with peripheral arterial disease. Other significant risk factors for flap loss include diabetes mellitus, venous insufficiency, underlying osteomyelitis, noncompliance, and age >40 years, all of which are common in the nontrauma heel ulceration cohort (19). Ducic and Attinger (20) found that diabetes did not have a direct impact on flap success; however, diabetes significantly increased the number of surgical debridements, increased the healing times, and decreased the long-term survival rate.

Total and partial calcanectomies are frequently used to treat recalcitrant heel ulceration both with and without osteomyelitis, with the aim of ambulation and wound closure (21,22). The benefits of the calcanectomies include removal of infected bone, decrease in plantar pressure, and reduction in bony prominences to allow for soft tissue closure (7). Since Gaenslen described the initial calcanectomy, the conventional partial calcanectomy has been portrayed as a viable alternative to a transtibial amputation (23). However, literature on the partial calcanectomy shows a wide variance of healing, reulceration, major amputation rates, and postoperative morbidity (23). The current literature on the partial calcanectomy reveals a lack of consensus on the amount of bone to resect or the alignment of the osteotomies (21,22,24). Because of the lack of evidence-driven guidelines, the amount of resected bone is typically guided by the presence of osteomyelitis (25). In patients who underwent partial calcanectomy secondary to a heel ulceration, 29% went on to BKA (2). The bone-to-soft-tissue ratio must be biased toward a soft tissue closure without tension, especially with postoperative edema (26). Although negative pressure wound therapy and bioengineered allografts with offloading show some success, evidence shows that early soft tissue coverage, especially with the unique fibrofatty heel pad, is key in preventing recurrent osteomyelitis (27). Certain technical drawbacks of the partial calcanectomies include fracturing resulting from weakening of the plantar cortex after osteotomy and delayed wound healing (2,28).

Major lower-extremity amputations are often used as definite treatment options if limb salvage is unobtainable because of the lack of acceptable surgical options. With diabetic foot ulcerations being the number 1 cause of BKA from nontraumatic causes (4), heel ulcerations are at an extremely high risk of amputation (1,22,26). The presence of osteomyelitis increases the rates of major lower-extremity amputation to as high as 52% (9). However, through a multidisciplinary approach, a limb salvage rate as high as 90% can be achieved (29). Although preservation of limb length is certainly a consideration, the main goal of limb salvage should not be focused on sparing the foot but on functional outcomes (30). Ambulation rates after BKA are often a debated topic. The study by Evans et al (3) showed a 30% rate of return to ambulation at 2 years compared with the historical range of 23% to 65% (3). A factor leading to such a low percentage is that many patients never fully learn to ambulate in their prosthetic after a BKA (31). Mortality rates in patients post-BKA are between 20% and 50% at 3 years (32,33) and 40% and 70% at 5 years (27,33).

To address a lack of evidence-based options between partial calcanectomy and major lower-extremity amputation, the VCC was introduced (2). With the ultimate goal of functional limb salvage, the VCC provides a functional alternative to the traditional partial calcanectomy while avoiding or delaying major lower-extremity amputation in cases of heel ulcerations. The VCC is a modification of the partial calcanectomy that provides a consistent approach and reproducibility. The VCC addresses the mechanical issues of the partial calcanectomy with resection of the tendoachilles, thus decreasing the stress on the plantar cortex and decreasing probability of fracturing (2). The VCC removes enough bone to allow for more soft tissue coverage and allow for resection of infected bone while maintaining a functional ambulatory limb (2).

The VCC is performed by creating a Gaenslen incision, elevating the soft tissue flaps, and transecting the Achilles tendon (2). Three cardinal osteotomies are performed: (1) a transverse cut in the lower half of the calcaneus resects the plantar portion, (2) a vertical cut parallel to the long axis of the leg is placed in posterior half of the superior cortex of the calcaneus, and (3) a 45° angled cut removes the sharp angle created by the first 2 cuts. Subsequent contouring creates a rounded surface for ambulation. Strict offloading of the lower extremity is recommended postoperatively until the patient is healed and fitted for proper offloading footwear (2). The preoperative radiography and clinical picture are shown in Figures 1 and 2, and the postoperative radiographs and clinical picture with soft tissue closure are seen in Figures 3 and 4.

Although fear of inducing an iatrogenic calcaneal gait from an aggressive Achilles resection is a concern of many surgeons, patients can maintain adequate ambulation with active pedal flexors to compensate. The results of this study corroborate this: 69% of patients at the 1-year follow-up maintained or improved their ambulatory status. These results are consistent with a study by Baravarian et al (26) showing loss of Achilles with proper orthoses maintaining similar ambulatory status and no appreciable subjective weakness. The authors have found that complete resection of the Achilles tendon with the VCC procedure will prevent the common complication of tongue-type calcaneal

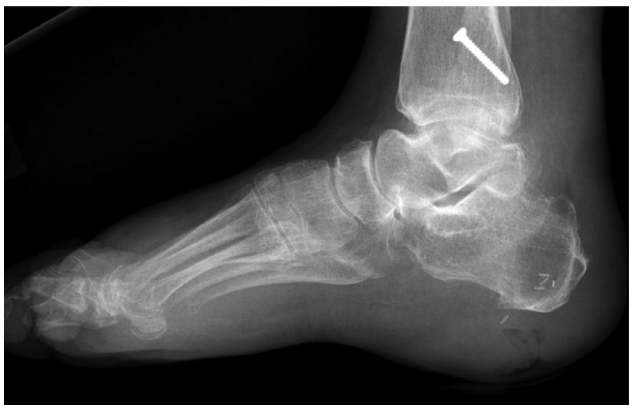

Fig. 1. Preoperative radiograph.

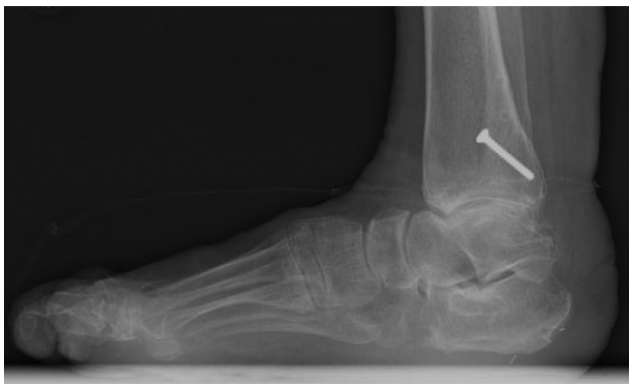

Fig. 3. Postoperative radiograph.

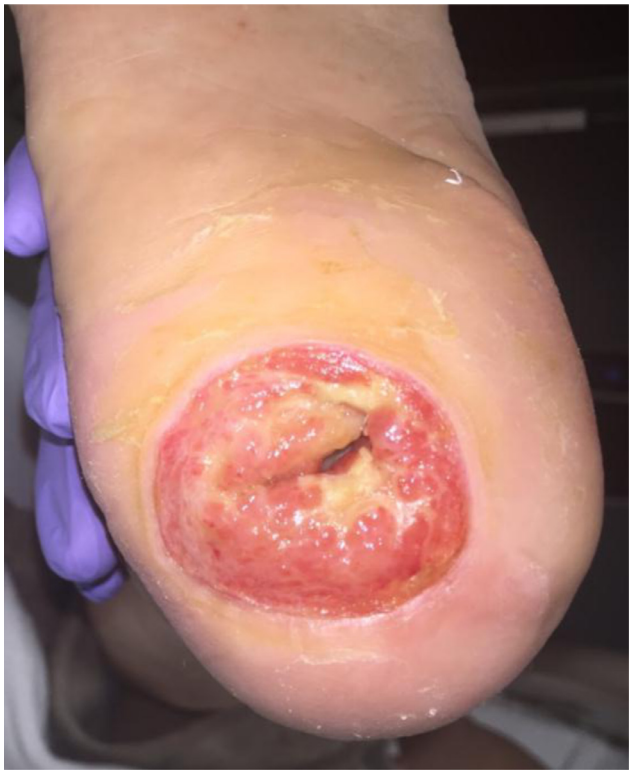

Fig. 2. Preoperative clinical photograph.

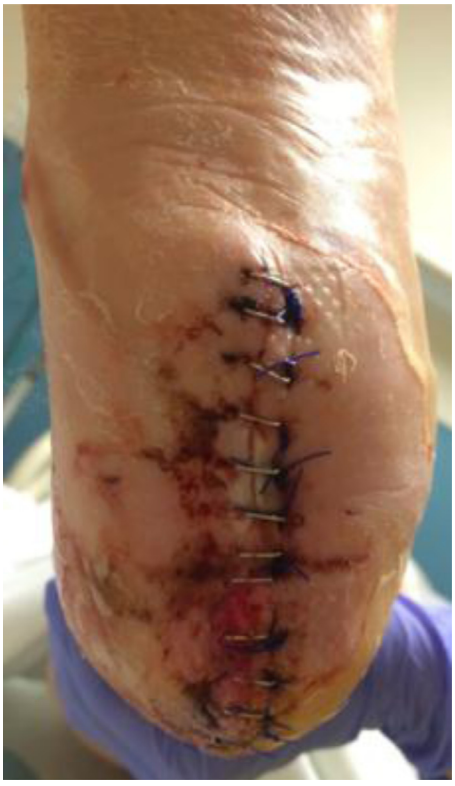

Fig. 4. Postoperative clinical photograph.

fractures, which can manifest with other partial calcanectomy techniques that preserve the insertion.

Additionally, the quantity of calcaneus bone removed in the VCC does not appear to affect patient function per the Lower Extremity Functional Scale (2). Given that limb length has a correlation to life expectancy, preservation of limb length using a VCC would decrease morbidity and mortality more effectively than BKA (3). We have found that the traditional partial calcanectomy angle of bone resection is often too acute for offloading plantar pressures. An osseous protuberance or abrupt cortical wall can lead to reulceration and increased risk of morbidity. Traditional partial calcanectomies have a major amputation rate of 52.5% (34). In contrast, the results of the VCC are promising: 50% of all procedures required no additional surgery, 81.25% of patients required 2 or fewer surgeries, and the total lower-extremity amputation rate was 18.8%. The authors note that resecting an aggressive portion of the calcaneus can yield better clearing of calcaneal osteomyelitis and also provides sufficient soft tissue flaps for coverage from medial and lateral full-thickness tissues.

Despite the increased difficulty of healing calcaneal wounds, the goals remain the same: elimination of infection, adequate soft tissue coverage, and optimization of functional outcome (35). Although other surgical options may exist, we believe the VCC is a methodical, reproducible surgical intervention that benefits patients with multiple comorbidities. This case series for the VCC shows promising results: 69% of patients at the 1-year mark and all of the patients at a 2-year follow-up returned to preulcerative ambulation status. Additional studies that incorporate longer-term follow-up with validated scoring systems, show correlation of outcomes to specific comorbidities, and prioritize patient satisfaction are necessary. The VCC should be considered as a valid, alternative, reliable surgical limb salvage tool for recalcitrant heel ulcerations.

In conclusion, given the extreme difficulty in treating heel ulcerations, and the lack of soft tissue coverage with the presence of the os calcis, the VCC has shown to be a viable alternative to major lower-extremity amputation. Long-term ambulatory status of patients treated with the VCC shows promise. The VCC should be considered as an alternative, reliable, surgical limb salvage tool for heel ulcerations.

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