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Plantar Approach for Midfoot Wedge Resection to Reconstruct the Rocker Bottom Foot

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ABSTRACT

Chronic deformity of the foot can lead to ulceration, infection, and amputation. Midfoot wedge osteotomy for deformity correction has been described in the literature; however, most reports are case review or small series. Wedge osteotomy can be performed from a medial or plantar approach, but there are limited data on outcomes regarding these relatively uncommon procedures. This study aims to review a population of patients with a rocker bottom foot deformity that underwent a midfoot wedge resection performed from the plantar surface for deformity correction, wound healing, and limb salvage. A review of medical records from a single foot and ankle surgeon was undertaken. Patients who had a midfoot wedge performed from the plantar surface to address rocker bottom deformity resulting from Charcot neuroarthropathy or severe flatfoot were included. Thirty patients met inclusion criteria. The outcome measures evaluated were minor and major complications, wound healing, and functional limb status. Statistical analysis was performed to evaluate factors that influenced outcomes. At time of final follow up, 17 of 20 (85%) preoperative wounds had healed. Mean preoperative talo-first metatarsal angle was −25° and improved to −5° postoperatively. An 87% limb salvage rate (26/30) was demonstrated. Body mass index was the only statistically significant factor that influenced functional limb status. Maintaining a functional limb can have profound effects on a patient's quality of life. Generally, patients with this severe rocker bottom foot deformity have multiple comorbidities and are at an increased risk of major amputation and early death. The current study has shown that patients with a rocker bottom foot deformity can benefit from midfoot wedge resection from a plantar approach to achieve a plantigrade foot.

Chronic foot deformities are a difficult problem and can dramatically affect patients' quality of life (1,2). Chronic deformity of the foot can lead to ulceration, infection, and amputation. A rocker bottom foot is 1 of these difficult deformities. A rocker bottom foot deformity is defined as a plantar convexity of the foot, rather than a concavity found in a normal foot structure (3). The apex of this deformity is usually at the midtarsal joint and can be identified radiographically by evaluation of the talo-first metatarsal angle and/or evaluation of the lateral column (Fig. 1). This deformity can be the result of many pathologies, including severe flatfoot, congenital defects, systemic arthridities, and Charcot neuroarthropathy (CN).

Schon et al (4) reported that CN is a common condition that can lead to a rocker bottom foot. It is a pathologic process that leads to joint destruction and deformity, most commonly involving the foot and

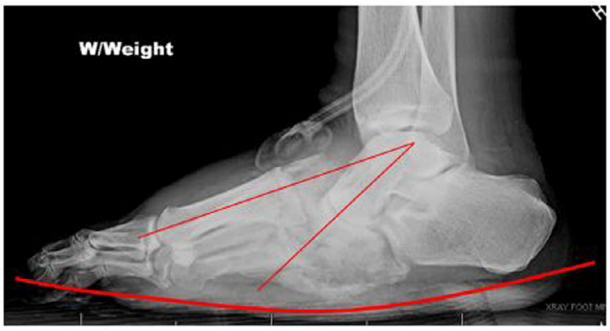

Fig. 1. Rocker bottom deformity with an increase in talo-first metatarsal angle.

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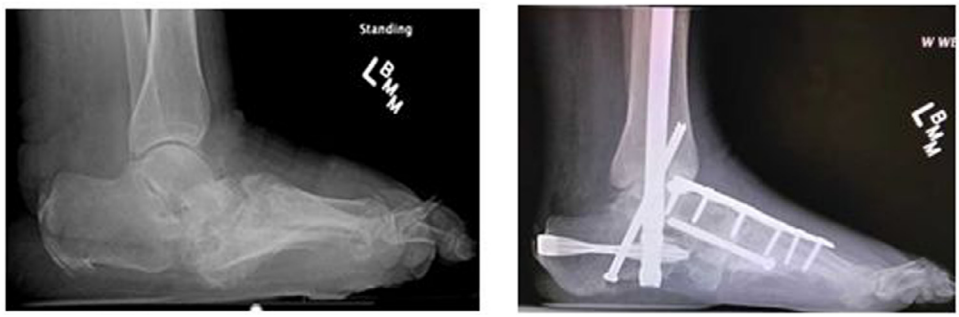

Fig. 2. Preoperative (left) and postoperative (right) radiographs of a rocker bottom deformity and internal fixation techniques following midfoot wedge osteotomy.

ankle. CN is often seen in profoundly neuropathic patients that continually ambulate on an injured lower extremity, leading to fractures and bone fragmentation. This can happen anywhere within the foot and ankle; however, the midfoot is most common. CN occurs 40% of the time within the tarsometatarsal joint complex and 30% within naviculocuneiform, talonavicular, and calcaneocuboid joints (5). Midfoot CN can be problematic, often leading to a rocker bottom deformity and ulcerations caused by pressure resulting from bony deformation (6). This process poses an extreme challenge to foot and ankle specialists. Patients diagnosed with CN are faced with many challenges, including higher comorbidities, gross instability of the foot and ankle, and higher risk of ulcerations and major amputations (1,2,7,8).

Surgical treatment for patients with plantar prominence can vary from simple exostectomies to complex realignment reconstruction procedures. If the treatment consists of a realignment reconstruction of the rocker bottom foot, it can be very challenging (3). Often, reconstructing a foot with an open wound or a history of infection can lead to an even higher rate of complication (8). It may be unwise to use internal fixation

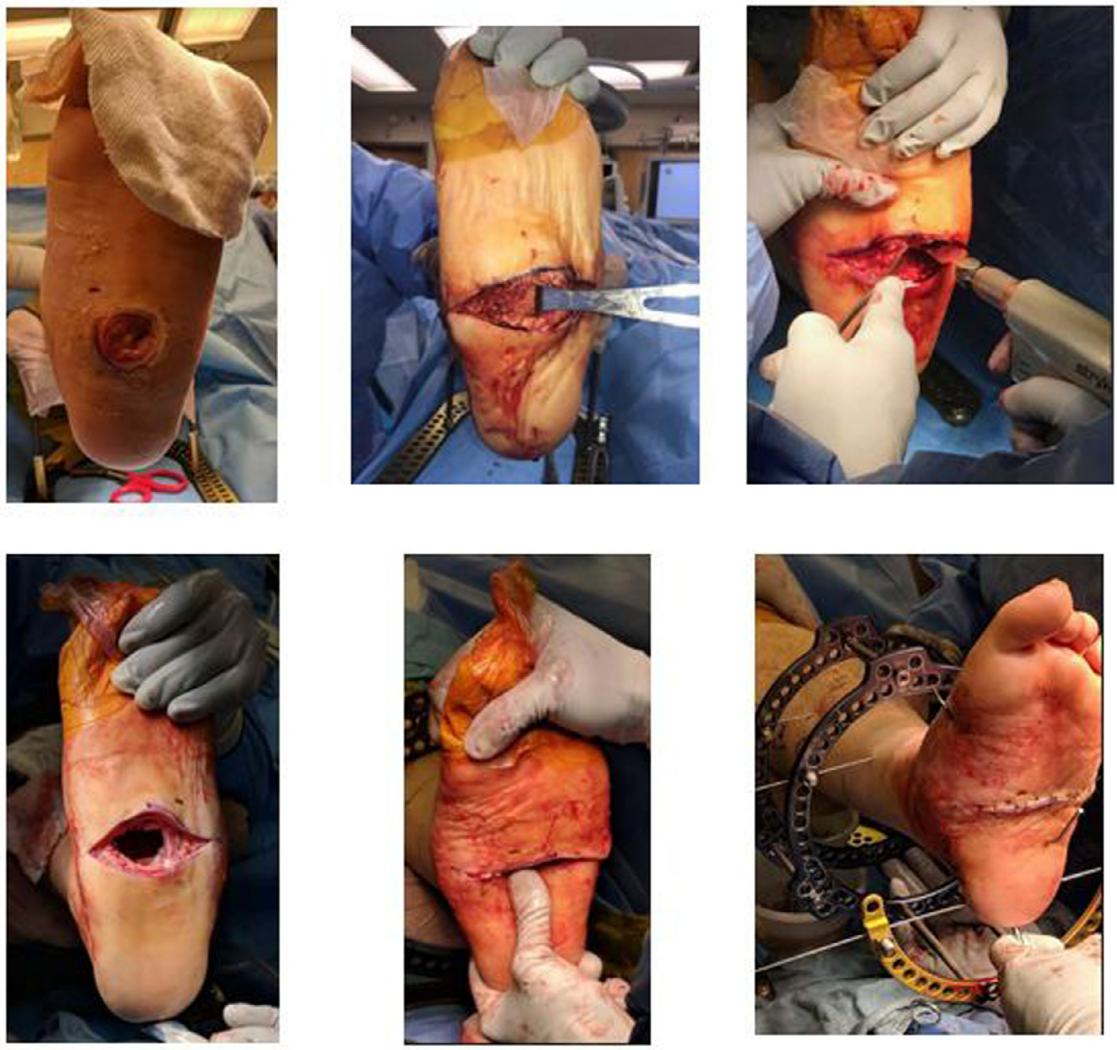

Fig. 3. Intraoperative midfoot wedge osteotomy (in order, from left to right). Note primary closure of the plantar wound following the wedge osteotomy.

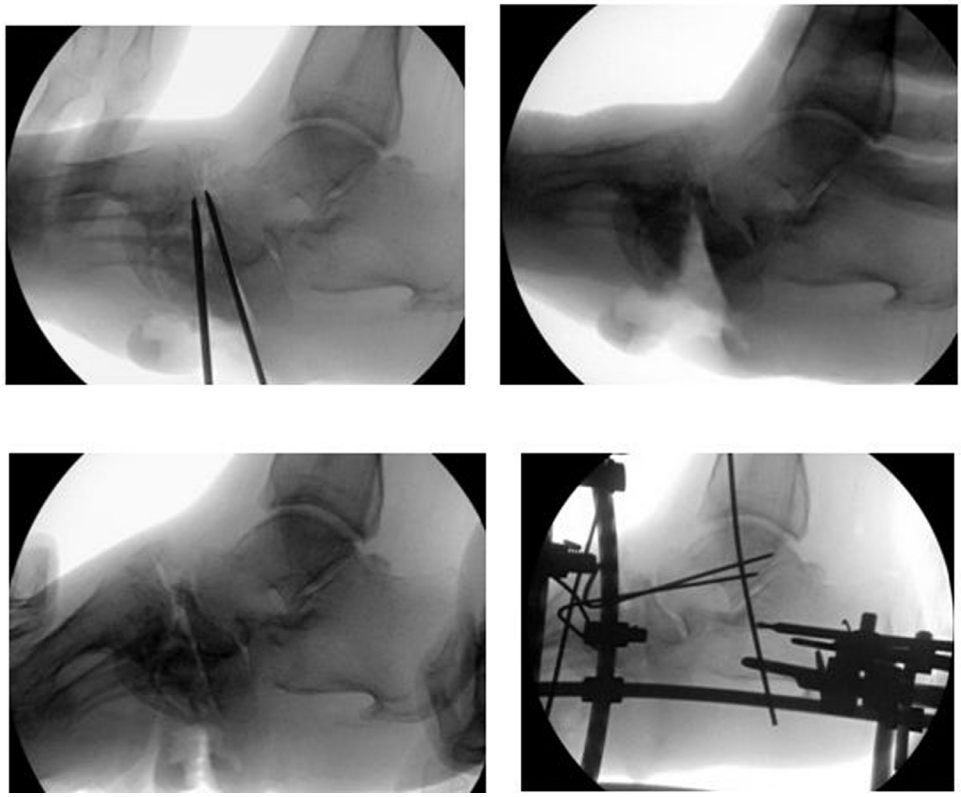

Fig. 4. Intraoperative fluoroscopy during the osteotomy (in order, from left to right), with closure of the osteotomy and application of external fixation.

while reconstructing a foot with an ulceration or infection present. In the presence of a wound, with or without infection, a staged reconstruction with the use of external fixation may be necessary. The deformities are often nonreducible and rigid. Normal anatomy can be skewed and the standard approach to joint preparation and realignment becomes difficult (8). If the deformity is rigid and no longer anatomic, an osteotomy is frequently required. The authors of this study describe a plantar-based midfoot wedge osteotomy performed with a plantar approach to grossly realign and recreate an "arch" throughout the midfoot.

The purpose of this study is to review a population of patients with a rocker bottom foot deformity that underwent plantar approach midfoot wedge resection for deformity correction, wound healing, and limb salvage. This study will also evaluate treatment outcomes. The authors hypothesize that the plantar approach to a midfoot wedge osteotomy allows for wound healing, deformity realignment reconstruction, and limb salvage in the rocker bottom foot. This study describes a staged technique for reconstruction of the rocker bottom foot that uses a combination of external as well as internal fixation. The authors also describe their use of external fixation to aid in healing plantar foot wounds and treating infection prior to subsequent internal fixation.

Materials and Methods

After institutional review board approval was obtained, medical records were reviewed for patients matching our criteria containing "midfoot wedge" or "midfoot osteotomy." The authors reviewed 30 patients (30 feet) that underwent midfoot wedge resection performed from a plantar approach for correction of a rocker bottom foot deformity that were followed from March 2008 to November 2017. This represented a single surgeon series (P.B.) from a single institution. All patients in this study presented to our institution for treatment of a chronic foot deformity in an attempt at limb salvage.

Patient electronic records were reviewed and the following information was extracted: presence of a rocker bottom foot deformity, presence of an ulceration (from partial thickness to full thickness, including bone involvement) and/or infection at initial presentation, presence of diabetes (as diagnosed previously), presence of CN (as diagnosed clinically by red, hot swollen foot or via radiographic analysis), age, sex, body mass index (BMI), and laterality. Outcome measures included the presence of a wound at final follow up, change in talo-first metatarsal angle based on lateral radiograph, postoperative complications (minor and major), incidence of major amputation, and incidence of functional limbs at final follow up. Minor complications were defined as those not requiring unplanned return to the operating room (OR), with major complications defined as those that did require an unplanned return to the OR. Reasons for return to the OR were management of infection, nonunion requiring revision, unplanned hardware removal, and/or amputation. Functional limb status was defined as a limb that was stable, plantigrade, and ambulatory, either with or without the assistance of custom orthopedic bracing. Major amputation was defined as above or below knee amputation. Only patient charts that included all of this information were included. Patients with incomplete follow up/charts were excluded. Statistical analysis was completed by a university research statistician to evaluate factors that influenced patient outcomes. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Patients were treated in either a single or staged fashion. Patients without a wound or infection and whose deformity could be reduced acutely were treated in single-stage fashion. The single-stage procedure consisted of a plantar approach midfoot osteotomy with a plantar-based wedge for deformity correction. Internal fixation was generally used for fusion across the osteotomy site. Additional fusions were performed when needed and consisted of triple arthrodesis or pan-talar arthrodesis. Preoperative and postoperative radiographs are shown in Fig. 2. Additional concomitant procedures included forefoot realignment procedures and gastrocnemius recession or Achilles tendon lengthening and were done at the primary surgeon's discretion.

Those patients with a wound and/or infection, or whose deformity could not be reduced acutely, were generally treated with a staged procedure. The first stage consisted of a plantar-based wedge resection performed from the plantar surface with deformity correction. Reduction was maintained with the application of external fixation. If there was a plantar wound, the wound was excised as part of the surgery; the plantar-based wedge osteotomy was made through this wound. If there was suspicion for infection, deep tissue and bone cultures were obtained. Infection was treated with serial debridements, local antibiotic beads, and systemic antibiotics per the infectious disease team. In some cases, after excision of the wound and deformity correction, primary closure was obtained. In cases in which the wound was too large and could not be completely closed, local wound care was performed until closure. Figs. 3, 4, 5A, and 5B show clinical and radiographic intraoperative images of the procedure. Following treatment of the wound and infection, the external fixator was removed; a second procedure consisting of internal fixation was performed to achieve fusion and maintain correction was then performed. Arthrodesis and additional procedures were performed in a similar manner as previously described for the single-stage approach.

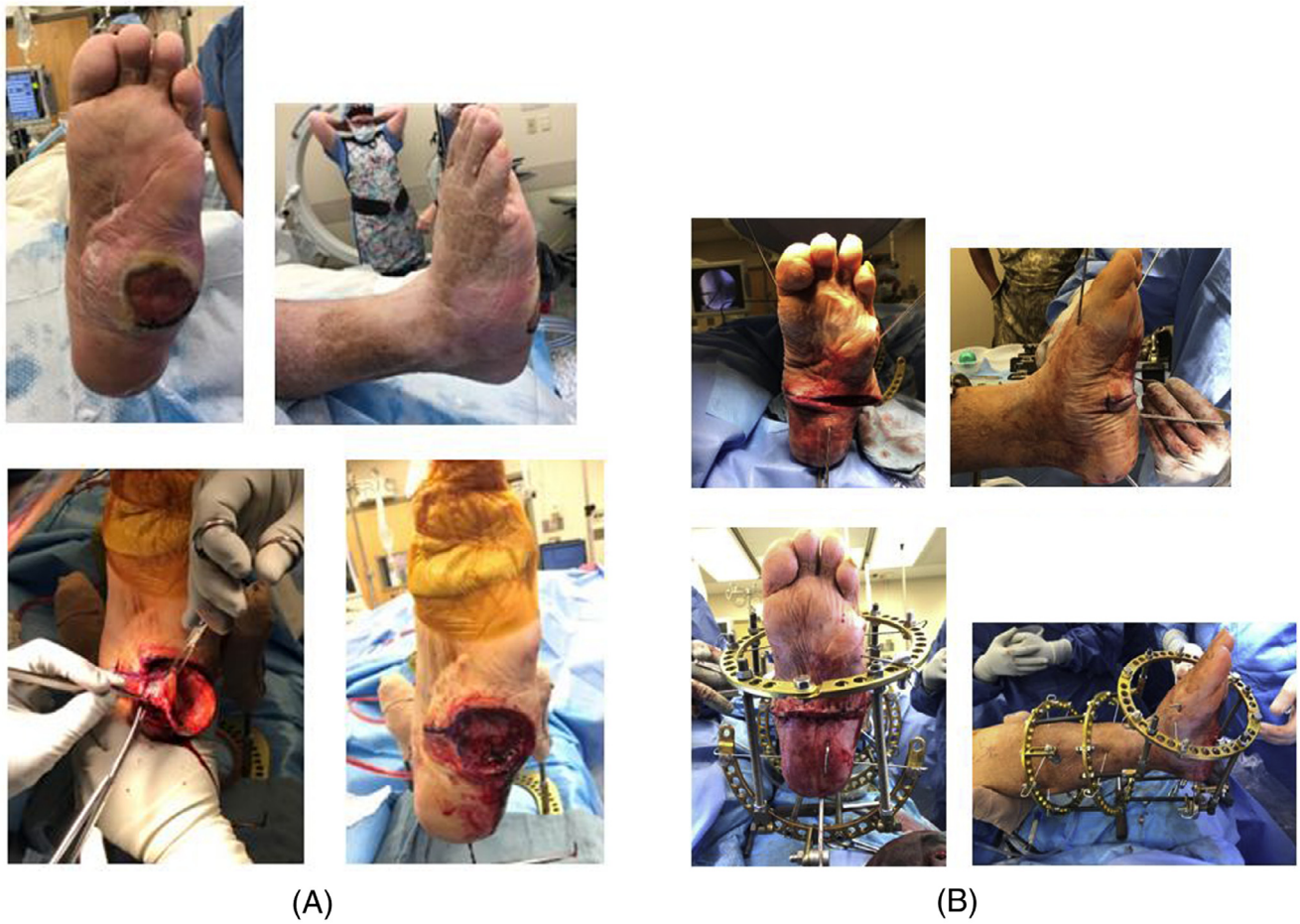

Fig. 5. (*A*) Preoperative lateral midfoot ulceration and rocker bottom deformity (top) and intraoperative ulcer excision (bottom). (*B*) Intraoperative deformity reduction after midfoot wedge osteotomy (top) and intraoperative photo demonstrating use of external fixation to maintain and stabilize deformity correction (bottom).

Results

After chart review, we found a total of 30 patients (30 feet) who had undergone a midfoot wedge osteotomy via plantar approach; these were reviewed (Table 1). The mean age was 59 ± 11 (range 35 to 78) years. Mean follow up was 29 ± 23 (range 7 to 97) months. Mean BMI was 35 ± 9 (range 23 to 61). Mean preoperative talo-first metatarsal angle measured on lateral radiograph was −25°; this improved to −5° postoperatively. There were 25 of 30 patients (83%) with diabetes and 27 of 30 (90%) patients had a diagnosis of CN. At the time of initial procedure, 20 of 30 patients (67%) had 1 or more wounds; 15 of those 20 wounds were infected. Osteomyelitis was present in 10 of the 15 infections, whereas the other 5 were confined to the soft tissues. Of the 20 patients with preoperative wounds, 16 underwent a staged procedure with external fixation and wound/infection treatment followed by internal fixation. At last follow up, which was a mean of 29 ± 23 (range 7 to 97) months, 17 of 20 (85%) preoperative wounds had healed (Figs. 6 and 7). Three patients had a new wound that was in a new location at time of last follow up. External fixation was used in 18 of 30 (60%) patients, and all 18 eventually had internal fixation placed. Of the 18 that required external fixation, 13 (72%) had a diagnosis of preoperative infection, 8 of which were positive for osteomyelitis. Patient characteristics (diabetes, CN, presence of wound, presence of infection, age, sex, BMI, use of external fixation) were tested for an association with patient outcomes (presence of a wound at final follow-up, post-operative complications (minor and major), incidence of major amputation, and incidence of functional limbs at final follow-up) using Wilcoxon rank sum test, Fisher's exact test, and Kruskal-Wallis test. At the time of last follow up, there was an 87% limb salvage rate (26/30). BMI was the only characteristic with a statistically significant relationship to any of the outcomes, namely functional limb status. Nonfunctional limb BMI average was 50, whereas functional limb BMI average was 32 ($p = .02$). A total of 2 patients died resulting from septicemia; 1 patient underwent major amputation and died while undergoing treatments, and 1 patient had chronic deep infection that lead to septicemia and died after refusing amputation. Of the 4 nonfunctional limbs, 2 had a history of deep infection preoperatively. Postoperative complications occurred in 18 of 30 patients (60%), with 15 being major and 3 being minor (Tables 2 and 3). We were not able to detect a significant relationship between postoperative complications and any of the patient characteristics. Out of 15 patients who had a preoperative infection, 9 (60%) had postoperative complications (7 major and 2 minor). Of the 18 patients who had

Table 1
Patient characteristics and data

Diabetes	25/30 (83)
Charcot	27/30 (90)
Presence of wound	20/30 (67)
Presence of infection	15/20 (75)
Age, y	59 (38-74)
Sex	8 females, 22 males
Body mass index	35 (23-61)
Staged with external fixation	18/30 (60)

Data are presented as N (%) unless otherwise noted.

Fig. 6. (Top) Preoperative clinical rocker bottom deformity with midfoot ulceration. (Middle) Intraoperative photos with deformity correction and primary closure of ulcer. (Bottom) Healed ulcer with maintained deformity correction.

external fixators, 9 (50%) had a postoperative complication (7 major and 2 minor). Of the 25 patients with diabetes, 15 (60%) exhibited a postoperative complication (13 major and 2 minor). There were 3 of 5 patients (60%) without diabetes that experienced a complication (2 major and 1 minor). We were not able to detect a statistically significant difference in complications between patients with and without diabetes.

Discussion

Managing limb-threatening rocker bottom foot deformities is difficult for the foot and ankle surgeon (3). Chronic foot and ankle deformity can quickly lead to ulceration, which increases the risk of infection and amputation (9,10). The presence of diabetes, neuropathy, CN, and other comorbidities confounds the difficulty of managing these cases (9,10). The plantar-based midfoot wedge osteotomy performed from a plantar approach described in this study addresses the rocker bottom deformity at its apex. Although the complication rate was relatively high, the current technique demonstrated an 87% limb salvage rate. This is comparable to other studies looking at limb salvage rate in severe lower extremity deformities (11–13).

Maintaining a functional limb can have profound effects on a patient's quality of life (14). Morbach et al (9) showed that major predictors of death of diabetic patients include age, being male, chronic

Fig. 7. (Top left) Preoperative midfoot ulceration. (Top right) Deformity correction with use of external fixation. (Bottom) Healed ulceration and maintained deformity correction.

renal insufficiency, dialysis, and PAD. Generally, patients with CN have multiple comorbidities and are at an increased risk of early death (10). Major amputation only propagates this statistic. Similar to other reports, Gurney et al (15) showed a 57% mortality rate at 3 years for diabetic patients undergoing major amputation.

There are limitations of this study that merit discussion. First, this study was a retrospective review; consequently, the data collection may be incomplete. Although only complete records were included in

Table 2
Factors associated with complications (N = 18)

Complications Associated With	Major	Minor
Preoperative infection	7 (39)	2 (11)
External fixation	7 (39)	2 (11)
Diabetes	13 (72)	2 (11)
Without diabetes	2 (11)	1 (6)

Data are presented as N (%) unless otherwise noted.

Table 3
Major and minor complications (N = 18)

Major	
Deep infection required hardware removal	5/18 (28)
Required revision midfoot osteotomy and pantalar arthrodesis	3/18 (17)
Deep infection leading to septicemia and death	2/18 (28)
Deep infection required major amputation	1/18 (6)
Chronic osteomyelitis, nonambulatory, refused BKA	1/18 (6)
Periprosthetic fracture, required longer IM nail	1/18 (6)
Tibial stress fracture above IM nail, healed without surgery	1/18 (6)
Required additional plantar exostectomy	1/18 (6)
Minor	
Original wound reopened, no infection	1/18 (6)
Unrelated ankle fracture while on vacation	1/18 (6)
Hardware failure	1/18 (6)

Data are presented as N (%) unless otherwise noted.
Abbreviations: BKA, below-the-knee amputation; IM, intramedullary.

this study, the results rely on the accuracy of previous documentation. A second important limitation of this study is the small sample size of patients. Although 30 patients comprise a relatively large cohort undergoing reconstruction, this study is likely to be underpowered to detect statistically significant findings regarding some of the variables and may not give an accurate representation of patients with this deformity. As such, the reader should interpret our findings within the context of these limitations. Outcome bias is also potentially present because the senior author determined the entire treatment plan and other surgeons may have addressed this pathology differently.

In conclusion, the current study has shown that a midfoot wedge osteotomy performed from the plantar surface can be performed in patients with severe rocker bottom foot deformity with success. This technique allows for the restoration of a plantigrade foot by effectively recreating an arch that is functional for the patient. In turn, it is the hope of the authors that these patients can have a better quality of life.

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