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Viability of permanent PMMA spacer with combined free fasciocutaneous tissue transfer for failed charcot reconstruction: A 38 month prospective case report



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ABSTRACT

INTRODUCTION: Charcot Neuroarthropathy is a complex lower extremity pathology which predisposes the afflicted limb to ulcerations, osteomyelitis, and risk of major amputation. Charcot Neuroarthropathy often requires osseous reconstruction, which can be complicated with osteomyelitis and hardware infection. When soft tissue and osseous deficits must be concomitantly addressed, the use of PMMA spacers can be combined with free tissue transfers.

PRESENTATION OF CASE: 71 year old Caucasian male with Diabetic Charcot Neuroarthropathy underwent osseous reconstruction with internal hardware. The surgical site was complicated by acute infection, osteomyelitis, exposed hardware requiring removal, and multiple surgical débridement. The degree of soft tissue and osseous deficit post-débridement required complex reconstruction.

DISCUSSION: The osseous deficit was addressed with the use of a permanent PMMA cement spacer. The soft tissue deficit was reconstructed with a free tissue transfer. This case report demonstrates the long term viability and utility of the use of permanent cement spacers when combined with free tissue transfer for closure of complex diabetic foot wounds. This case is an example of a multidisciplinary team approach to limb salvage with successful long term outcome; a plantigrade stable functional foot in an ambulatory highly active patient. Follow up time since initial intervention was 38 months.

CONCLUSION: The use of a permanent PMMA cement spacer does not preclude free tissue transfer in complex host lower extremity reconstruction. A multidisciplinary team approach is a vital component to successful salvage outcomes.

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1. Introduction

Diabetes is a chronic systemic metabolic disease with a profound effect on health. With a growing prevalence expected to exceed 430 million individuals worldwide by the year 2030 [1], it becomes exceedingly important to understand, and manage the complications associated with diabetes. Charcot Neuroarthropathy (CN) is a devastating, limb threatening condition predominantly seen in patients with diabetes. CN results in profound destruction to the foot and ankle resulting in neuropathic ulcerations, and often complicated with infection of the skin and soft tissues

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and/or bone. For many patients, wide excisional débridement is required emergently. Alternatively, patients, as a consequence of CN deformity, with or without ulceration require surgical reconstruction as prophylaxis against future ulceration and amputation [2]. Determination of superimposed osteomyelitis is critical to aid surgical management and establishing a framework for post-operative function and ambulation [3,4]. The use of permanent Polymethylmethacrylate (PMMA) cement spacers can provide a viable reconstructive option in an effort to re-establish a stable plantigrade biomechanically functional foot. Use of antibiotic eluting cement spacers (PMMA-AEC) can also mitigate bacterial burden to local tissue, permit earlier wound closures, and enhance the delicate long term outcomes of the diabetic foot [5]. Wound coverage after soft tissue and bone loss requires careful planning for complete and sustained closure. Free tissue transfers, when performed after preoperative screening for candidacy, remains a formidable



Fig. A1. Preoperative non-weight bearing radiographs.

tool in the hands of experienced surgeons who operate within the context of a multidisciplinary Limb Salvage Team [6,7].

The utility of PMMA has been widely accepted in the Orthopaedic and Faciomaxillary literature and widely used in spine surgery and large joint arthroplasties [8,9], and its inclusion in the lower extremity has grown progressively popular over the past 60 years [10,11]. PMMA is a synthetic polymer which is mixed and molded in-vitro producing an exothermic reaction which precludes the use of many common antibiotics [12]. Often the cement is enhanced with one or more heat stable antibiotic powders. The safety of PMMA with and without antibiotic enhancement has been thoroughly studied in the literature [13].

We present a case with permanent PMMA spacer application in reconstructive limb salvage efforts. This case represents our longest follow up of 38 months. The patient was evaluated from initial presentation at the Center for Wound Healing at MedStar Georgetown University Hospital to time of publication; an academic center dedicated to limb salvage. The use of gold standard medical and surgical intervention, the use of a permanent PMMA spacer, and closure with a free fasciocutaneous tissue transfer resulted in ongoing success for our patient. This surgical case report complies with the consensus guidelines of the SCARE criteria [14].

2. Presentation of case

Our patient was a 71-year old Caucasian male with a past medical history of Hypertension, Hyperlipidemia, and Type 2 Diabetes Mellitus complicated by Peripheral Neuropathy, Charcot Neuroarthropathy and a previous smoking history. He presented to a community podiatric surgeon for treatment of a chronic



Fig. A2. Post-debridement photographs.

non-healing medial plantar ulceration secondary his CN induced deformity. The surgeon opted for a single staged débridement of the right foot and reconstruction to prevent future complications. An intramedullary rod was introduced into the head of the first metatarsal and beamed through the medullary canal passing through the base of the metatarsal, medial cuneiform, and the navicular (Fig. A1). Subsequently, the patient returned to the surgeon with fevers and an acute postoperative infection with surgical site dehiscence, exposed hardware, and actively draining purulence. The patient underwent débridement and was placed on culture driven intravenous Clindamycin 600 mg every eight hours via a peripherally inserted central catheter for MSSA. He was discharged with Negative Pressure Wound Therapy, a posterior splint and subsequently referred to our multidisciplinary limb salvage team.

Initial assessment revealed an unstable Charcot foot with soft tissue and osseous infection. A right dorsal foot wound measured 10.5 cm × 2.5 cm × 2.0 cm. The patient was admitted and provided empiric intravenous antibiotic coverage with vancomycin/piperacillin tazobactam, and emergently surgically debrided of all infected and nonviable soft tissue and bone. The exposed hardware was removed and the surgical canal after removal of the beam was reamed and lavaged. (Fig. A2) Vancomycin powder was topically administered to the surgical site including the medullary cavity. The next day the patient underwent right lower extremity endovascular angiography without the need for intervention. He was consented for additional débridement during which new intraoperative cultures were obtained. A concern for medial column and midfoot osteomyelitis resulted in additional surgery with resection of the proximal first metatarsal, medial cuneiform, and the navicular. A Vancomycin/Gentamycin PMMA-AEC spacer to the right medial column was placed and NPWT with instillation of normal saline was applied (Fig. B1). This was tran-



Fig. B1. Postoperative weight bearing radiographs.

sitioned to NPWT without instillation upon discharge. The patient was re-examined on an outpatient basis with interval assessments of glucose, HbA1c, nutrition markers, CRP, and clinical evidence of adequate granulation formation. Because granulation tissue formation was suboptimal, and the large size of the soft tissue deficit a free flap was deemed necessary. After cardiovascular assessment, and a thorough evaluation by plastic surgeon (KKE), the patient was found to be a good candidate for free flap surgery. A final débridement guaranteed healthy tissue, eradication of infection and the placement of a new permanent PMMA spacer. A thin fasciocutaneous free tissue flap was raised from the patient's left forearm with elevation of a portion of the brachioradialis muscle. Following anastomosis of the vessels, and inset of the flap, a split thickness skin graft was harvested and applied to the left forearm.

Postoperatively, the patient only required 2 additional débridement with the application of a bilayered collagen graft and continued local wound care to both the right foot and the left arm and proper offloading to both surgical sites (Fig. C1).

Patient had close postoperative follow up, and has been seen periodically for past 3 years and prospectively assessed for efficacy of this technique. Initially, the patient was seen weekly for the first month, followed by a bimonthly follow up interval until he was completely weight bearing. We continue surveillance and risk assessment on a monthly basis. He remains ulcer free, and ambulates without assistive aids. He is able to tolerate regular shoe

gear without difficulty and maintains an active lifestyle golfing on a weekly basis (Fig. D1).

3. Discussion

3.1. Bone cement spacers

The advent of acrylic bone cement dates to 1901 with the first clinical orthopedic applications in 1940's [8]. When implants and/or hardware become infected, use of PMMA-AEC provides structural stability and local bacterial eradication when used as a temporary spacer [15]. Generally, PMMA-AEC spacers and beads have been used as a temporary means; employed intermittently between débridement and definitive closure. The clinical utility of bone cements in the lower extremity relies on its biocompatibility and mechanical properties [16]. There is however a paucity of studies relating to permanent application of PMMA spacers in the foot, with an even lesser degree related to the pathologic diabetic foot [17]. A study by Elmarsafi et al. published in 2017 report the salvage rates of permanent PMMA spacers in the infected foot as 66.7% in 30 high risk patients including 9 with CN. Furthermore, they report the mean time to spacer failures as 20.9 months, mean follow up 52 (12–111) months, longest retained spacer 76 months, and longest exchanged spacer was 111 months [17]. PMMA is a dense monolithic minimally porous material. Antibiotic elution therefore is limited to the contact surface. Because the admixing of the polymer and catalyst produces an exothermic reaction, the choice of antibiotics is limited to those which are heat stable. In-vivo, the exothermic reaction is between 40 and 57 °C; a threshold that is below the temperature that may cause denaturation of host proteins and has not been shown to induce thermal osteonecrosis [18,19]. Elution occurs in three phases: an initial burst occurring in the first 24 h, a progressively decreasing rate of elution in the 2–14th day, after which clinically insignificant release continues until a steady state has been reached [20,21]. The most commonly used antibiotics added to PMMA are gentamicin, tobramycin, and vancomycin. The bacterial coverage of these antibiotics lend well to diabetic foot infections and osteomyelitis [22]. Parenteral culture driven antibiotics must be used irrespective of antibiotic loading (Fig. D2).

The surgical inclusion of PMMA cement spacers in the foot and ankle include temporary and permanent applications and can be implanted with or without antibiotic loading. Placement after joint resection maintains structural length which prevents soft tissue contractures and potential "kinking" of vascular structures. Cement can be fashioned in-vivo to best approximate the native osseous anatomy. Care should be taken not to form a spacer that is too bulky which can predispose to ulcerations. This is particularly true when the spacer is in close proximity to the weight bearing aspect of the foot. A spacer that is too small may migrate which may lead to structural instability as well as predispose to ulcerations.

3.2. Free fascio/musculocutaneous tissue transfers

Reconstructive surgery is a vastly diverse field in which strategic manipulation of the host tissue can drastically improve both form and function. The populations at highest risk for lower extremity infections and amputations often have a complex medical history which may preclude them from free flap candidacy. Surgical and medical optimization and a risk versus benefit analysis should take place between the patient, and a plastic surgeon. The ultimate goal should be centered on residual function, and mitigating biomechanical stresses of the affected limb. The anatomic options available for defect coverage depend on the vascular integrity of the donor and recipient sites, the size and depth of the deficit, and the



Fig. C1. Interval postoperative clinic photographs.



Fig. D1. 38 month postoperative clinic photographs.



Fig. D2. 38 month weight bearing radiographs.

technical skill and competence of the surgeon. Donor site morbidity is always taken into consideration, and wound healing modalities may need to be employed for extended periods of time. Although, some sites can be primarily closed, surgical site complications must be monitored postoperatively. The patient may need cardiovascular evaluation to ensure that the patient can safely undergo the lengthy anesthesia and surgical risks. Free flap closure of complex wounds in the lower extremity can be the difference between a major amputation or successful salvage [23,24].

3.3. Reconstruction alternatives

The diabetic CN compromised foot presents multiple clinical challenges. The medical complexity of the host, the biomechanical implications, and suboptimal osseous quality impart high lower extremity major amputation rates in this population. Recurrence of joint collapse and the sequelae of re-ulcerations and infection to the bone and soft tissues result in exceedingly burdensome healthcare utilization, and a decrease in patient quality of life. In many circumstance, particularly in those who are active, a primary below knee amputation may be a viable solution. For those cases in which an attempt for salvage is possible, the ultimate goal must aim for eradication of infection; address the structural and functional integrity of the limb, and the timely and long lasting soft tissue closure.

Osseous defects can be filled with autologous harvest if the deficit is small. However, larger deficits require other osteoconductive means for bridging defects. The use of cadaveric and synthetic allografts avoids donor site morbidity. Whether autograft or allograft bone is used however, hardware fixation is required. In the setting of a previously infected surgical site, timing of implantation is essential to ensure complete eradication of infection. Because of underlying diabetic osteoporosis, and superimposed disuse osteopenia, the hardware required for good bony purchase involves twice the hardware when compared to non-diabetic counterparts [25]. Hardware failures, non-unions, and infections are common.

An osteocutaneous free flap with skin paddle is another alternative which can address both the osseous and soft tissue defects. Harvest however is limited by the size of the osseous deficit. Osteocutaneous flaps have been extensively described in the literature for the repair of facio-cranial defects and in the upper extremity. However, there is limited literature in lower extremity cases. In the diabetic population, the risks of donor site morbidity and osseous

non-union have not been quantified. There are no reported cases of osteocutaneous free flaps in patients with CN.

4. Conclusion

The use of PMMA spacers can be an invaluable tool in high risk Limb Salvage patients. After eradication of infected and devitalized soft tissue and bone, a careful assessment of the remaining soft tissue deficit and limb function should be undertaken. Functional outcomes can be improved with application of a PMMA spacer safely when applied in addition to standard treatment modalities. Care must be taken to ensure proper fit, shape and size of the spacer. A high pressure area can predispose to new ulcer formation if the spacer is too bulky or misplaced. A staged approach is preferred. When the reconstructive ladder is exhausted, permanent PMMA-AEC spacers do not contraindicate free tissue transfer. The combination of free flap closures and use of permanent PMMA-AEC spacers can be powerful, effective, and sustainable limb salvage modalities in the management of complex biomechanically compromised Charcot cases.

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Author contribution

All authors have contributed in all aspects in the development and writing of this manuscript.

Guarantor

Tammer Elmarsafi, DPM, MBBCh.

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