



The Feasibility of Peripheral Nerve Stimulators for Management of Limb-Threatening Ischemic Pain

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Introduction

Neurostimulation has been used for a long time as an analgesic modality for a wide variety of pain conditions with evidence of some benefit. Historically, use of this modality has been limited by technological confines, the invasiveness of lead placement, and cost of the procedure. Recent developments in percutaneous peripheral nerve stimulation (pPNS) technology has allowed for the minimally invasive placement of percutaneous peripheral nerve stimulator leads under ultrasound guidance in a similar manner to continuous peripheral nerve catheters.[1] Recent studies demonstrated the benefit of pPNS in the perioperative setting for a variety of surgical cases.

Several case series and a recent multicenter randomized controlled trial have shown improved outcomes with the use of pPNS for chronic lower extremity post-amputation pain.[2] The RAAPM team at Penn State Hershey has been investigating the benefit of pPNS for patients in the perioperative and sub-acute setting post-amputation. Investigation into the longer-term efficacy of pPNS for chronic pre-amputation ischemic pain is limited. Previous neuromodulation research for this subset of patients largely has focused on the use of spinal cord and dorsal root ganglion stimulation.[3] The pain associated with chronic ischemia is of large concern for patients and society in the era of the opioid epidemic as opioid medications are a mainstay in the treatment regimen for most of the patients with severe pain secondary to chronic limb ischemia. Determining alternative methods of pain control could help reduce opioid consumption in this population.

There exists a subset of patients whose peripheral artery disease is not critical enough to warrant amputation while also having no option for further revascularization. These patients also may have extreme ischemia-generated limb pain that is refractory to all traditional pharmacologic and procedural intervention. Up to 34 percent of patients with critical limb ischemia are not eligible for revascularization interventions.[4] Palliative amputation is as a method sometimes used to relieve this intractable ischemic pain. We present a small, limited study from our institution evaluating the feasibility of performing percutaneous peripheral nerve stimulators for this population to assess whether pPNS may be a viable option for reducing pain, increasing functionality, and potentially delaying or preventing limb amputation.

Methods

We received Penn State University IRB approval (STUDY00024034) to retrospectively examine the effects pPNS placement had on qualifying patients’ self-reported pain levels, subjective functionality assessments (e.g. increased ability to perform ADLs, increased exercise tolerance, etc.), and use of prescribed pain medication (if applicable). A total of eight patients had percutaneous peripheral nerve stimulators placed due to pain secondary to chronic limb ischemia. All patients had end-stage lower limb peripheral artery disease unresponsive to medical therapy. All patients’ pathologies were not amenable to surgical intervention besides palliative amputation. For the pPNS lead implantation(s), each patient was alert and able to give feedback about the location and sensation elicited when the pPNS was placed to ensure this was reproduced in their areas of pain. pPNS placed for femoral, saphenous, and/or sciatic nerves were placed by a RAAPM attending anesthesiologist. Prior to the pPNS procedure, informed consent was obtained from patients to use their de-identified information and data for scientific publications and presentations. Patients were contacted weekly by representatives of SPR Technologies to assess patient-reported pain scores, pain medication use, and for any troubleshooting that was necessary. The patients then returned to the clinic to have pPNS removed after 60 days.

Results Table

Patient	Date of pPNS lead placement	Highest recorded % Pain Relief	Nerve(s) Targeted	Self-Reported Change in Prescribed Pain Medication Requirements	Self-Reported Change in Quality of Life
1 ⁱ	6/24/2021	40%	Femoral	No change	Unable to assess well prior to amputation
2 ⁱⁱ	7/30/2021	Noted moderate pain relief at week 1 check in	Sciatic	N/A	N/A
3	12/24/2021	50%	Sciatic	No Change	Improved
4 ⁱⁱⁱ	12/30/2021	50%	Sciatic (Popliteal)	Unknown	Unknown
5	12/22/2022	90%	Femoral and Sciatic	Decreased	Much improved
6	4/17/2023	100%	Sciatic (Popliteal)	Decreased	Much improved
7 ^{iv}	8/31/2023	0%	Femoral and Sciatic	No change	No change
8	9/29/2023	90%	Femoral and Sciatic	No change	Improved

i: Pt not controlled well enough after placement to avoid a below the knee amputation, which occurred 6/30/2021. Pt kept stimulator leads in for 60 days with noted results.
ii: Pt expired approximately 2 weeks after lead placement
iii: Difficult follow-up. No response to inquiry after post procedure week 2. Patient did not follow up for lead extraction, which occurred outside of our facility
iv: Patient had femoral and sciatic leads placed initially. His sciatic lead was dislodged approximately one week after placement. Presented to the hospital within two weeks of placement and underwent subsequent above the knee amputation during hospitalization.

Discussion

Percutaneous peripheral nerve stimulators have shown positive results in small studies and case reports for chronic lower limb pain of various etiologies.[5] Patients with chronic limb ischemia often experience significant pain, impaired wound healing, decreased mobility, and lower quality of life. Revascularization is the first-line therapy; although some patients are poor candidates due to physiologic or anatomic reasons. Traditional medical therapies benefit many of these patients, allowing them to maintain semi-functional lives at minimum. However, mainstay pharmacological therapies for these patients rely heavily on opioid medications that have significant risks, side effects, and addiction potential. Unfortunately, there are some whose pain is too debilitating despite traditional efforts, requiring amputation to ameliorate pain and improve quality of life.

Neuromodulation has been investigated as an alternative, non-pharmacologic form of analgesic treatment for patients with chronic ischemic pain. However, this research has largely been focused on spinal cord stimulation and, more recently, dorsal root ganglion stimulation. These modalities are more invasive than pPNS, requiring surgery for lead and generator implantation. The neuraxial location and implantation present larger risks that are not associated with pPNS placement. pPNS leads are less invasive than neuraxial stimulators and are temporary by design. Though temporary, there appears to be a sustained analgesic benefit from pPNS that significantly outlives the 60 days implantation period.[2] Though the aim of this feasibility project was not to track longer-term outcomes, one patient (Patient 5) admitted to being pain free for over 11 months after pPNS placement. Unfortunately, we only learned this because the patient eventually presented for an amputation due to critical progression of his peripheral artery disease, involving complete occlusion of the superficial femoral artery. The artery was only approximately 70 percent occluded when the pPNS was placed.

Given the positive results seen with the patients in the study, it appears that pPNS could provide significant long(er) term benefit to patients dealing with debilitating pain secondary to chronic limb ischemia. The minimally invasive and temporary nature of pPNS reduces the larger risks, surgeries, and cost associated with other neuromodulatory methods that have been used to treat pain associated with chronic limb ischemia. The duration of analgesic benefit of pPNS is still not well known, but it appears that pain reduction lasts beyond the implantation period. Additionally, pPNS procedures are repeatable if the analgesic effect eventually wanes. This feasibility project suggests a bigger prospective trial is warranted to evaluate the role of percutaneous peripheral nerve stimulators for these patients.

References

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