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Minimally Invasive Peripheral Neuromodulation for Postamputation Stump Neuroma: A Case Report

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Background: Postamputation neuromas are a significant cause of pain and suffering in amputees. In patients who are nonresponsive to medical therapy, open surgery is often required but has limited efficacy.

Case Report: Here we present a case of the successful use of percutaneous peripheral nerve stimulation in a 77-year-old man with a postamputation neuroma that was refractory to medical therapy. He had significant pain reduction allowing a return to his daily activities.

Conclusion: This case report demonstrates that peripheral nerve stimulation may reduce pain in patients with post-amputation neuroma. Percutaneous peripheral nerve stimulation is a promising treatment to reduce pain and improve patient function without irreversible manipulation.

Key words: Case report, neuromodulation, peripheral nerve stimulation, postamputation pain, stump neuroma

BACKGROUND

Residual limb pain following amputation is a significant source of suffering among the amputee population. There are approximately 185,000 amputations per year, and nearly 2 million amputees are currently living in the United States (1). Following amputation, 95% of amputees report suffering from some type of amputation-related pain in the previous 4 weeks (2). Of these, approximately 25% have secondary neuroma formation (3). Pain due to neuromas significantly impedes prosthesis use and limits normal activities of daily living (4). As a result, many patients have a measurable decline in their quality of life that many attribute to their pain as opposed to the loss of their limb (5).

Despite the increased prevalence of postamputation pain, treatment options remain limited. Initial management consists of various pharmacological agents and injections. Medical treatments have variable efficacies, but ultimately may require escalation to surgical interventions. Even with traditional surgery, approximately 20% to 30% of neuromas remain symptomatic (6). Recent advances in neuromodulation have presented an alternative to more irreversible surgical treatment. Here we report the successful use of an external pulse emitting neuromodulation device for the treatment of stump pain secondary to a neuroma.

CASE

The patient was a 77-year-old man with a right lower extremity amputation 30 years ago presenting with 4 years of right stump pain. Initially, after the amputation, the patient had limited discomfort, but he suffered a fall 4 years ago with a right femur fracture. He has suffered from stump pain since the fall. The patient reported a decreasing efficacy of his medical pain management; it has resulted in more frequent use of lidocaine patches

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and an increasing dose of gabapentin. Also, he has had local nerve blocks and phenol injections at the neuromas without significant improvement. Magnetic resonance imaging demonstrated both a tibial nerve neuroma and a common peroneal nerve neuroma (Fig. 1).

Physical exam indicated a positive Tinel's sign on the distal portion of his stump, proximal to a tibial nerve neuroma. We conducted a nerve stimulation trial at 0.6 milliamps and 0.3 milliamps with good effect. The patient reported a decline in his pain from 7 of 10 to 0 of 10. The patient elected to proceed with a right-sided placement of a percutaneous nerve stimulator on the sciatic nerve under conscious sedation and local anesthesia (7). Following positioning, the sciatic nerve was located using ultrasound at the midthigh; the entry was 8 cm lateral to this point, and the test leads were run under ultrasound guidance to good effect (Fig. 2A). The permanent lead was placed and tunneled superiorly and superficially (Fig. 2B). One month postoperatively, the patient reported at least a 70% pain reduction. Overall, the patient was satisfied with his procedure; he was able to return to his previous activities.

DISCUSSION

Chronic pain is a significant cause of morbidity in patients following amputation. As a result of their pain, patients experience both physical and psychological suffering as their diminished ability to participate in normal activities (4). Despite this, there is no standard protocol for postamputation pain, typically consisting of a combination of medical and surgical management.

First-line treatment typically involves pharmacological therapy, including antidepressants, anticonvulsants, and analgesics such as opioids (8). These medications have varying levels of tolerability and efficacy. Further medical management may consist of steroid injections or chemical ablation with alcohol and phenol (8). Patients often require continuous escalation of therapy, as demonstrated by the patient presented here. This patient had been managed medically for many years. Still, after an acute accident, the patient had worsening symptoms that could not be covered with increasing medication dosages and phenol injections.

Following the failure of medical management, surgery may be offered. Traditional surgical treatments may consist of excision followed by burying of the nerve end into either muscle, bone, or vein. The nerve end may also be capped or anastomosed to another nerve – though studies into the various techniques have been limited, and none has proven to be superior (6). In a meta-analysis conducted by Poppler et al (6), surgical treatment effectively controlled neuroma pain in 77% of patients. However, the authors noted that reoperation rates are

Fig. 1. Coronal view of T1-contrasted magnetic resonance imaging that reveals the 2 neuromas: common peroneal (A) and tibial (B) neuromas.

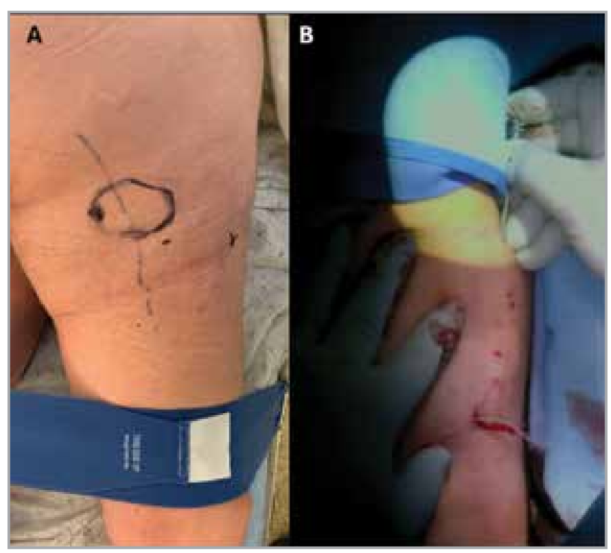

Fig. 2. 2A: Ultrasound was utilized to localize the sciatic nerve (circled) and an entry point was approximated 8 cm laterally (dot). 2B: After the appropriate lead placement, the distal portion was tunneled superiorly and laterally.

often not reported and may be as high as 65%. Regrowth is inevitable following the neuroma excision, and success depends on a less symptomatic neuroma (9).

Recent advances in neuromodulation technology have allowed this to be another viable treatment modality of peripheral nerve pain. Neuromodulation for peripheral nerve pain includes spinal cord stimulators (SCS), electrical nerve blocks, and peripheral nerve stimulators (PNS). SCS have been frequently used with good response for the treatment of neuropathic pain. However, the evidence for their use to treat peripheral neuropathic pain, such as postamputation pain, is less promising (10). The use of SCS for peripheral nerve pain is also limited by its inability to create discrete stimulation fields, and any associated complications from operating on the neuroaxis (7).

Another alternative is electrical nerve blocks; this involves the implantation of a device around the nerve as well as an implantable generator that delivers high-frequency alternating current (HFAC) (11). This treatment option behaves similarly to a lidocaine nerve block, inactivating sodium channels as a result of continuous HFAC membrane depolarization. It has demonstrated efficacy in animal models as well as in a clinical pilot study by Soin et al (11). Patients with medically intractable limb pain experienced a significant decrease in pain, a decrease in the use of pain medication, and a reported decrease in functional restrictions durable beyond 12 months postoperatively. While promising, this modality requires a larger-scale study. Additionally, this treatment requires invasive, open procedures for placement of a cuff around the target nerve as well as implantation of an internal generator.

Recent innovations have led to the development of dedicated PNS. Initially, PNS were repurposed, off-label SCS (5). As a result, outcomes were affected by different technical complications associated with adapting SCS to the peripheral tissue and neural structures. These included lead migration and lead destruction because of increased strain experienced in the periphery than initially designed for. In recent years, dedicated PNS have undergone several technological advancements and have demonstrated promising outcomes in reducing

Table 1. Review of surgical and neuromodulation options including indications for each as well as their outcomes. Outcomes in surgical treatment options for neuroma were obtained from meta-analysis by Poppler et al (6).

Surgical Treatment Options for Painful Neuroma		
Surgery	**Procedure Description**	**Proportion of patients with reduction in pain by surgery type (6)**
Excision and coverage	Excision of neuroma and coverage with a free flap. Addition of flap may improve nutrition, decrease scar adhesion, and offer protection from surface insults (18).	0.78 (95% CI, 0.59-0.98)
Excise and transpose (vein or muscle)	Excision of neuroma and transposition into either a vein or a muscle. Transposition into a vein may decrease the chance of neuroma reformation while transposition into a muscle offers protection from mechanical irritation (19).	0.81 (95% CI, 0.76-0.86)
Excise only	Excision of painful neuroma with no additional steps.	0.74 (95% CI, 0.63-0.84)
Excise and repair	Excision of neuroma with neurorrhaphy	0.65 (95% CI, 0.48-0.83)
Neuromodulation for postamputation pain		
Surgery	**Procedure Description**	**Proportion of patients with reduction in pain by surgery type (6)**
Spinal cord stimulators	Implantation of a spinal cord stimulator. This technique lacks the ability to create discrete stimulation fields and requires an operation directly in the neuroaxis.	65% mean subjective pain reduction (20)
Electrical nerve block	Placement of a device around the nerve that generates alternating current. This requires an open, invasive procedure to place a cuff around the nerve.	73% pain reduction at 12 months (11)
Peripheral nerve stimulators	Peripheral nerve stimulation requires percutaneous placement of leads and a transcutaneous power supply. Minimally invasive procedure that may be done under local anesthetic.	88% experienced clinically significant pain reduction (5) Significant decrease in pain measures, opioid use, and pain interference in function (13,14)

peripheral nerve pain. This modality may be especially effective when pain is confined to one or 2 nerves, as is often seen in postamputation pain (5).

In their first iterations, the implantation of a PNS required careful open dissection and implantation of an internal generator (5). This required specific surgical training to achieve appropriate deep placement that was often complicated by lead migration or failure of placement requiring reoperation (12). Then, Rauck et al (5) demonstrated that PNS leads could be implanted percutaneously under image guidance and achieve effective pain reduction in neuropathic postamputation pain without needing direct contact. A follow-up study by Gilmore et al (13,14) replicated the substantial reduction in pain and demonstrated a reduction in required opioid medication and pain interference with function. In addition to these findings in postamputation neuropathic pain, percutaneous PNS devices have been demonstrated to be effective in treating nonamputation-related chronic peripheral nerve pain (15).

These findings demonstrate that percutaneous peripheral nerve stimulation is an effective modality for the treatment of postamputation pain. This minimally invasive technique requires less training, time, and money. In addition, the percutaneous leads are specifically designed to anchor into tissue and reduce migration leading to more durable results (16). The transcutaneous power supply eliminates the need for generator replacement and the common complaint of generator site pain.

Our case study used a percutaneous PNS placed through a simple stab incision under ultrasound guidance for the treatment of postamputation neuroma pain that resulted in significant pain reduction (7). These findings are similar to a report by Meier et al (17), who demonstrated significant pain reduction using peripheral nerve stimulation for postamputation neuroma pain.

Our experience demonstrates that this minimally invasive technique may be an effective treatment of refractory postamputation neuroma pain. With these advances, PNS convey several advantages in the treatment of postamputation pain (PAP). Foremost, they may be placed in a minimally invasive manner and do not obviate a need for an internal generator. Additionally, their use does not preclude further surgical interventions if required. Combined, peripheral nerve stimulation is an effective and reversible treatment modality to serve as a bridge between medical and surgical management for stump neuroma.

CONCLUSION

Chronic pain is a significant cause of morbidity in postamputation patients. Treatment of PAP remains challenging, often consisting of a combination of medical and surgical management. This case illustrates the successful treatment of a stump neuroma with peripheral nerve neuromodulation. This is a promising treatment to reduce pain and improve patient function without irreversible manipulation.

Author Contributions

DB: Writing, editing, literature review
CB: Writing, editing, literature review
LD: Editing, figure creation, assistant surgeon
ER: Editing, primary surgeon

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