

Management of Unreconstructable Saphenous Nerve Injury with Targeted Muscle Reinnervation

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Summary: Neuroma pain significantly impacts patient quality of life and is associated with unemployment, chronic opioid dependence, and depression. Targeted muscle reinnervation (TMR), a surgical technique that coapts proximal stumps of cut nerves to distal motor nerves of adjacent muscles, has demonstrated efficacy in the treatment and prevention of neuroma pain. The objective of this study was to describe the surgical technique for TMR of the saphenous nerve, while providing a retrospective review. Between January 2015 and December 2018, 18 patients underwent TMR of the saphenous nerve: 1 nonamputee patient with chronic pain after ankle surgery and 17 amputee patients (10 for relief of chronic post-amputation neuroma pain and phantom pain and 7 at the time of amputation for prevention of these symptoms). Six patients were lost to follow up; 2 patients had recurrent pain; and 10 patients had reduced or no pain after TMR surgery. TMR is a successful technique for the management of traumatic neuroma pain in both the amputee and nonamputee populations, and in this study, we describe the technique for saphenous nerve TMR. (*Plast Reconstr Surg Glob Open* 2020;8:e2383; doi: 10.1097/GOX.0000000000002383; Published online 17 January 2020.)

INTRODUCTION

Targeted muscle reinnervation (TMR) is a surgical technique that coapts the proximal ends of cut nerves to small motor nerve branches of nearby muscles. Initially developed for intuitive myoelectric prosthesis control, the technique has subsequently been found to improve neuroma pain and phantom limb pain in the amputee population.^{1,2} Given its origins, most early descriptions have focused on the major mixed nerves of the upper extremity. Prior cadaver studies have described the anatomy of motor entry points in the upper and lower leg but with relatively few clinical examples of the treatment of specific nerves using TMR for neuroma pain.^{3,4} Although the treatment of injured nerves, conceptually, is best with the restoration of continuity either with direct coaptation, nerve grafts, and, more recently, nerve allografts, there are many situations (especially in amputees) where repair is not possible. In these situations of unreconstructable nerve injury, TMR is a helpful adjunct. We present the surgical anatomy of the saphenous nerve and treatment of unreconstructable saphenous neuromas at various levels with TMR.

COURSE OF THE SAPHENOUS NERVE

The saphenous nerve arises from the posterior division of the femoral nerve and provides sensation to the anteromedial aspect of the leg through 2 major divisions: the sartorial and infrapatellar divisions. In the proximal thigh, the saphenous nerve lies lateral to the femoral artery. It travels within the adductor canal, where it crosses medially over the femoral artery. It then exits the canal and divides almost immediately into its infrapatellar and sartorial branches.⁵ The infrapatellar branch travels anteriorly to supply the anteromedial knee. The sartorial branch continues underneath the sartorius and becomes subcutaneous by piercing the fascia between sartorius and gracilis tendons, posterior to the medial femoral condyle.^{6,7} It then continues down the leg just posterior to the medial tibia alongside the greater saphenous vein, running posteriorly to it.

OPERATIVE TECHNIQUE

In the proximal lower extremity, the saphenous nerve should be approached through an incision at the level of Hunter's canal, approximately 10 cm proximal to the medial femoral condyle, extending along the posterior axis of the femur. The saphenous vein is identified and retracted posteriorly. The fascia is then incised over the sartorius muscle. The nerve can be identified easily as it exits between the sartorius and gracilis muscles. It can then be followed deeper into the leg toward the adductor canal

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(Fig. 1A). At this stage, the vastus medialis is visualized, and the nerve stimulator can be used to localize a motor target, which is typically a relatively large (1–2 mm diameter) motor nerve found on the surface of the muscle. The saphenous nerve is then cut distally, and the motor target is cut as proximally as needed to achieve a tension-free nerve coaptation with 2 epineurial 6-0 Prolene sutures (Figs. 1B and 2).

In the distal leg, the saphenous nerve should be approached through an incision overlying the point of maximum Tinel's sign just posterior to the medial tibia, identified on preoperative evaluation. The motor target for TMR is selected based on proximity to the location of saphenous nerve injury. Incision placement and potential motor targets in the lower leg have been previously discussed.³

RETROSPECTIVE REVIEW

After institutional review board approval, patients who underwent TMR at Northwestern Memorial Hospital were

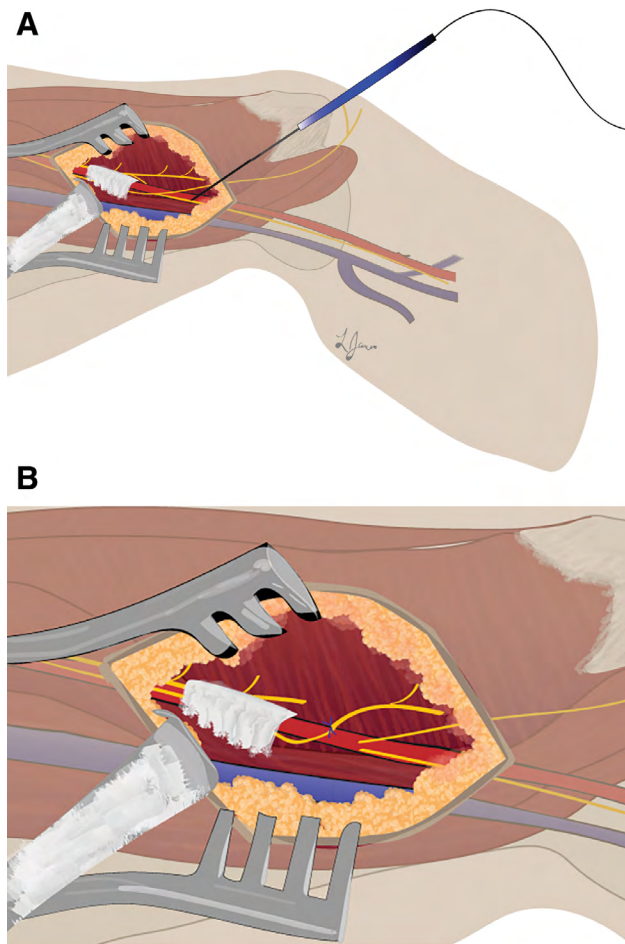


Fig. 1. Operative approach for TMR of the saphenous nerve in the upper leg. The nerve is identified as it exits from the adductor canal, and a nerve stimulator is used to assist in identifying a motor target (A). The distal end of the saphenous nerve is then coapted to the proximal end of a motor nerve branch to the vastus medialis with 6-0 Prolene suture (B).

reviewed. Between January 2015 and December 2018, 17 amputee patients underwent TMR of the saphenous nerve: 10 patients for relief of chronic postamputation neuroma pain and phantom pain, and 7 patients at the time of amputation for *prevention* of these symptoms. The most common target muscle was the vastus medialis, but alternatives included motor nerves innervating the biceps femoris and gracilis muscles for transfemoral amputees and medial gastrocnemius and medial soleus muscles for transtibial amputees (Table 1). Of the 10 patients who underwent TMR for chronic neuroma pain, 3 patients were lost to follow up, and 7 patients were seen 1–11 months postoperatively (average 4 months). Of these 7 patients, 2 patients had reduced pain, and 5 patients had complete resolution of pain. Of the 7 patients who underwent acute TMR at the time of amputation, 3 patients were lost to follow up, and 3 patients were seen 2–14 months postoperatively (average 6.67 months). All 3 patients denied development of neuroma pain.

In addition, 1 nonamputee patient underwent TMR of the saphenous nerve for unreconstructable neuroma pain in the distal leg. A 64-year-old woman presented to clinic with chronic ankle pain that started after she underwent an open reduction internal fixation of a left ankle fracture 5 years previously. During evaluation, her greatest Tinel's sign was noted at a previous incision over the medial malleolus, which resolved with lidocaine injection. She underwent TMR of the saphenous nerve to a motor point of the soleus muscle. She recovered well after surgery and maintains complete pain relief 6 months after surgery.

DISCUSSION

Neuroma pain is often described as “punishing-cruel” and “tiring-exhausting” on the McGill Pain Questionnaire and can significantly impact quality of life and function.⁸ Unfortunately, due to the lack of definitive treatments, opioids remain the cornerstone of neuroma pain management despite mixed efficacy.^{8–10} TMR has emerged as a successful tool for the management of traumatic neuromas and potential *prevention* of neuroma formation. A recent multi-institution, randomized trial found TMR performed at the time of amputation decreased long-term phantom and residual limb pain in major limb amputees.¹¹

We recommend TMR of the saphenous nerve for 2 indications: first, it can be part of the constellation of nerve coaptations to treat established pain in both above- and below-knee amputees. The second indication is recurrent neuroma pain after failure of neuroma excision and grafting. Although management of neuromas-incontinuity with excision and allograft placement is largely successful,^{12,13} a proportion of patients do not experience pain relief after this operation. For this group of patients with an intact limb, either neuroma excision with re-grafting or TMR is considered. In these patients, while TMR often helps local nerve pain, the surgery can result in distal dysesthesias, which should be discussed with patients preoperatively.

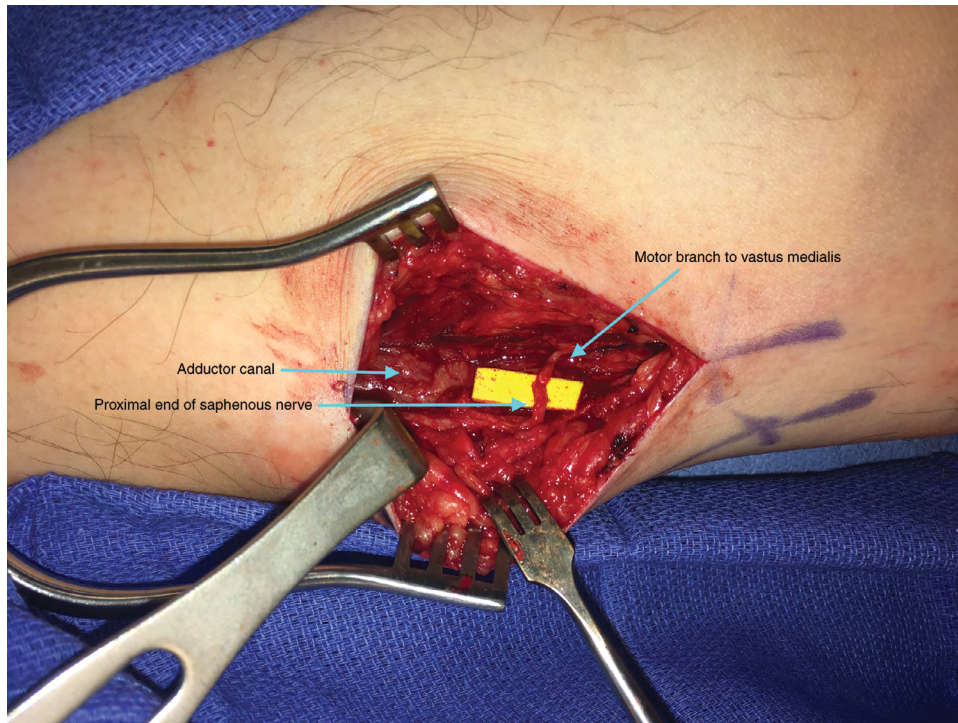


Fig. 2. Intraoperative view of saphenous TMR nerve coaptation.

Table 1. Demographics of Amputee Patients Who Have Undergone TMR of the Saphenous Nerve

Total	17 Patients
Man	13
Woman	4
Above knee amputation	10
Below knee amputation	7
Chronic amputee	10
Acute amputee	7
Biceps femoris	1
Vastus medialis	12
Gracilis	2
Medial gastrocnemius	1
Medial soleus	1

CONCLUSION

TMR has emerged as a successful technique for the management of traumatic neuroma pain in both the amputee and nonamputee populations, and in this study, we have outlined the anatomy of the saphenous nerve and described the surgical technique for TMR of the saphenous nerve.

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