

Targeted muscle reinnervation for a recurrent traumatic neuroma of the sural nerve: illustrative case

Mark P. van Opijnen, MD,¹ Hans Marten Hazelbag, MD, PhD,² and Godard C. W. de Ruiten, MD, PhD¹

Departments of ¹Neurosurgery and ²Pathology, Haaglanden Medical Center, The Hague, The Netherlands

BACKGROUND Traumatic neuromata often recur after resection. Recently, targeted muscle reinnervation (TMR) has been shown to be a promising alternative for the treatment of traumatic neuroma, also in nonamputees. This case shows that TMR can also be applied for this indication in recurrent traumatic neuroma.

OBSERVATIONS A 55-year-old patient with a history of cerebral palsy presented with a painful swelling in his right knee, 40 years after multiple Achilles tendon surgeries for contractures. On imaging, the lesion was suspect for a traumatic neuroma of the posterior sural nerve. After two failed resections, TMR was performed by connecting the proximal end of the sural nerve to the motor branch of the lateral gastrocnemius muscle. During outpatient visits at 3, 6, and 12 months, the patient reported significantly less pain compared to before the TMR. He had no weakness of plantar flexion. Postoperative imaging, however, showed atrophy of the lateral gastrocnemius muscle.

LESSONS This case shows that TMR can be a successful strategy to treat recurrent traumatic neuroma after previous failed transection of single neuromata in nonamputee cases. In the authors' patient, TMR did not result in motor deficit, but more research is needed to investigate this consequence of TMR for this indication.

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KEYWORDS gastrocnemius muscle; neuropathic pain; injury; recurrence; nonamputees

Traumatic neuromata develop after transection injuries of peripheral nerves in approximately 3% to 5% of patients.¹ Usually symptoms occur within several months after the nerve injury, but late manifestations have also been reported.²⁻⁴ There are several surgical options to treat traumatic neuromata, including resection of the neuroma; neuroorrhaphy; transposition into a muscle, bone, or vein; and neural capping with synthetic, biological, or autologous materials.⁵ Recently, targeted muscle reinnervation (TMR) has been shown to be a successful alternative. The concept of this technique is that regenerating axons are directed into another distal nerve target and thereby do not form another neuroma.⁶ Most research on TMR has focused on redirection of axons after amputation, but recently the first results were reported for a retrospective case series of 15 nonamputee neuromas in which TMR was performed.⁷

In this case, we describe the results for a patient with a traumatic neuroma of the sural nerve that developed 40 years after injury. After several attempts to surgically treat the neuroma, TMR

to the motor branch of the lateral gastrocnemius muscle was eventually performed.

Illustrative Case

Clinical History and Course

A 55-year-old patient presented with swelling in his right calf that was painful with bending of the knee. On magnetic resonance imaging (MRI), the lesion was suspect for a traumatic neuroma from the posterior sural nerve, just between the medial and lateral belly of the gastrocnemius muscle (Fig. 1). The neuroma had developed 40 years after multiple surgeries for lengthening of the Achilles tendon that had been performed to treat contractures due to spasticity of the right leg after birth-related cerebral palsy. On neurological examination, the patient had no weakness of plantar flexion function, but gait was abnormal as a result of spasticity of the right leg.

ABBREVIATIONS MRI = magnetic resonance imaging; TMR = targeted muscle reinnervation.

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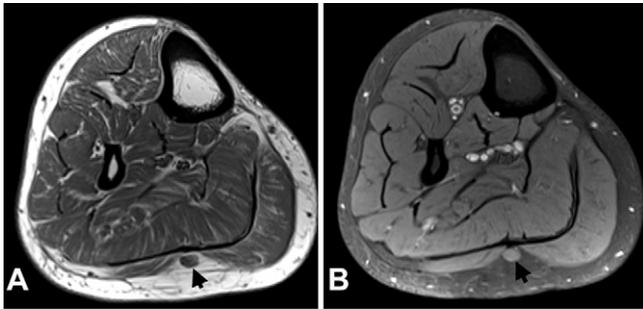


FIG. 1. Preoperative T1-weighted MRI shows the neuroma of the sural nerve (arrows) posterior between the medial and lateral belly of the gastrocnemius muscle, without (A) and with (B) contrast imaging.

Initial Resection

During the first surgery, the neuroma was resected and the proximal stump was covered with a steered-vascularized fat tissue flap. Pathological analysis showed a traumatic neuroma (Fig. 2A and B). Two months after the first surgery, the patient again developed pain symptoms with a positive Tinel sign. Sonographic analysis showed a thickened proximal nerve end suspect for a recurrent traumatic neuroma (Fig. 3A and B).

Reresection

During the second surgery, performed 6 months after the first surgery, there was again a clearly thickened distal end of the proximal stump of the sural nerve. Reresection of the traumatic neuroma was performed, including an extra segment of nerve, until the proximal end again had a normal caliber. Subsequently, this proximal end was sutured into a blind-ending nerve tube (NEUROCAP) (Fig. 4A). The patient initially recovered well from this surgery, but after 3 months he again experienced the same pain symptoms that he had before the first and second surgeries. This time, a second recurrence was suspected based on thickening of the nerve just proximal to the NEUROCAP (Fig. 3C and D). Because of the severity of the pain symptoms, explorative surgery was eventually performed 7 months after the second surgery.

TMR

The possibility of TMR was discussed preoperatively with the patient as well as the risk of postoperative weakness of plantar flexion function, and the patient consented to receive this surgical technique. Intraoperatively, the distal end of the sural nerve was dissected, and

together with the NEUROCAP, a segment was sent for pathologic analysis (Fig. 2C and D). The sural nerve was released in a proximal direction to obtain sufficient length for TMR. Subsequently, with the use of intraoperative nerve stimulation, the branch toward the lateral belly of the gastrocnemius muscle was identified. After transection of this branch, it was connected to the proximal end of the sural nerve (Fig. 4B and C).

Outcome and Follow-up

The patient showed good recovery directly after the operation. During outpatient visits at 3, 6, and 12 months, he reported significantly less pain. He now experiences only occasional pain, with a maximum score of 4 out of 10 on the Numeric Rating Scale (i.e., mild to moderate pain) compared to a score of 9 before the TMR procedure. After 1 year of follow-up, the patient was discharged from further follow-up. On neurological examination, he had no weakness of plantar flexion (Medical Research Counsel grade 5). MRI performed 12 months after the surgery, however, showed clear signs of denervation in the lateral belly of the gastrocnemius muscle (Fig. 5).

Discussion

In this case, we successfully treated a patient with a recurrent neuroma of the sural nerve that had developed 40 years after transection injury. Although we believed that the chance for successful pain relief would be small because of the long interval between injury and onset of symptoms together with two previous failed attempts to surgically treat the neuroma, the patient experienced complete pain relief, which was monitored up to 1 year after the TMR procedure.

Observations

This case report shows that TMR can be applied for surgical treatment of recurrent traumatic neuroma. We used the same technique and distal nerve motor branch to the lateral gastrocnemius muscle as in the first case reported by Fracol et al.⁸ More recently, results were reported in a retrospective cohort study for two patients with a traumatic neuroma of the sural nerve, one of whom received prior excision.⁷ Results for these three cases were successful for pain relief, and motor function was preserved. Nonetheless, the transection of the motor branch is not without risk for motor deficit. In our patient, we believed that the clinical consequence of motor weakness would be limited because of spasticity of the affected limb. Although subjectively and clinically muscle deficit was not detected postoperatively, the presence of atrophy on the postoperative MRI suggested that potential deficit should be discussed with the patient and weighed against other options to treat

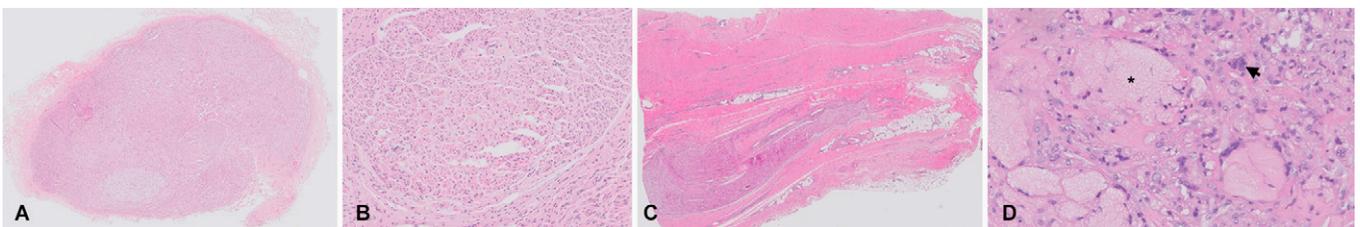


FIG. 2. Pathology images of slides taken from the proximal stump after the different procedures, all stained with hematoxylin and eosin (H&E). **A:** Transverse image showing an overview of the neuroma obtained from the proximal nerve stump after the first resection. **B:** H&E-stained image showing a pre-existent nerve fascicle (upper left) and a proliferation of mini fascicles and scar tissue (lower right). Original magnification $\times 100$. **C:** Longitudinal overview of the proximal part after transection together with the NEUROCAP. No neuroma can be seen in this part. **D:** H&E-stained slide of the stump in which foreign body material can be seen. Arrow points to a foreign body giant cell. Asterisk shows remains of the NEUROCAP. Original magnification $\times 100$.

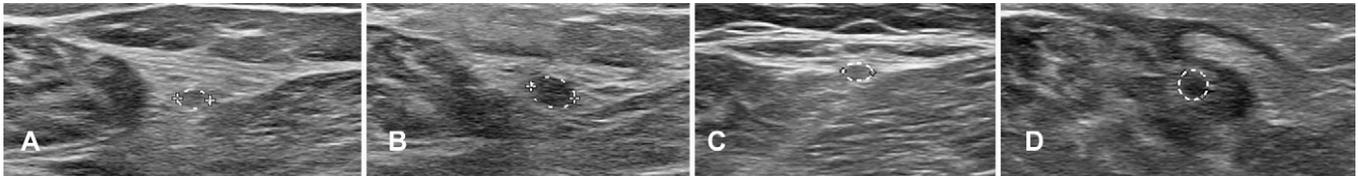


FIG. 3. Images obtained during sonographic analyses. Ultrasound showed a thickened proximal nerve end suspicious for a recurrent traumatic neuroma after the first resection: normal cross-sectional area (CSA) of the proximal part of the sural nerve (A) and a clearly increased CSA of the distal nerve end (B) compared with the CSA more proximally. The recurrence of pain after the NEUROCAP shows again a normal CSA for the proximal part of the nerve stump (C) and a clearly increased CSA of the nerve just proximal to the conduit (D).

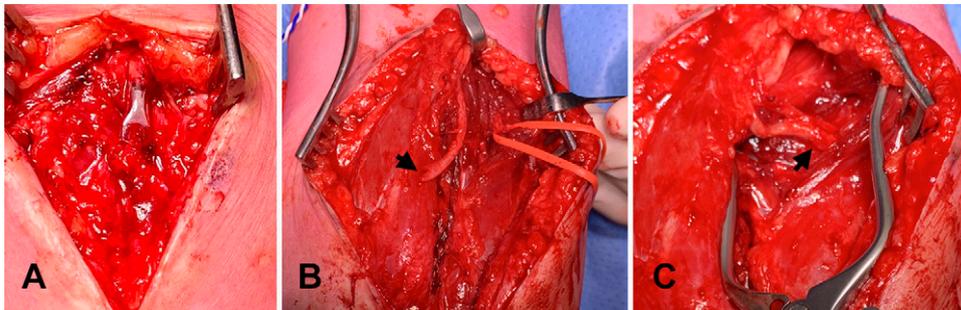


FIG. 4. Intraoperative images. **A:** The NEUROCAP at the distal end of the proximal sural nerve stump. **B and C:** The procedure for targeted muscle reinnervation. **Arrow** points to the proximal end of the sural nerve that has been dissected further proximally to obtain sufficient length for the TMR procedure (B). The vessel loop has been placed around the motor branch to the lateral gastrocnemius muscle (*right*). **Arrow** points to the coaptation of the proximal end of the sural nerve to the motor branch to the lateral gastrocnemius muscle (C).

recurrence of the neuroma. It is feasible to connect the proximal stump to a smaller, more distal branch by careful dissection of the motor branch into the distal target muscle until it arborizes, as pointed out by Chang et al.⁷ A potential downside of this technique, however, is that it results in a significant size mismatch between the donor nerve and the affected nerve, which may lead to a substantial escape of axons at the coaptation site and the formation of a traumatic neuroma.⁹ Although Chang et al. mentioned that all motor target nerves in their cases were redundant, their article did not clarify how this redundancy was determined.⁷

Lessons

The present case is thus unique given that our patient suffered from two previously failed surgeries before TMR was performed

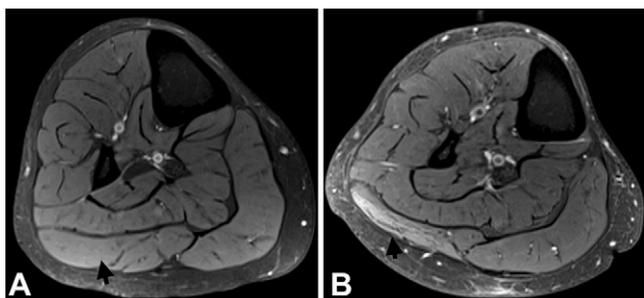


FIG. 5. Postoperative T1-weighted MRI with contrast 12 months after surgery shows high signal intensity suggestive of edema together with decreased size of the gastrocnemius muscle (B, *arrow*) compared to the situation before surgery (A, *arrow*).

and the fact that TMR was performed with an interval of more than 40 years between the initial trauma and our procedure.

There are several explanations for failure of the first two resections. As for recurrence of symptoms after the first resection, coverage with a vascularized fat flap has been shown to increase the risk of recurrence by hiding, rather than healing, the transected nerve end.⁶ Second, it is known that capped nerve ends may still form neuromas; consequently, the NEUROCAP is not necessarily the ultimate solution.¹⁰ These neuromas may still be painful, as shown in our case, which may be caused by traction on the neuroma or proximal nerve end (so-called mechanosensitivity).¹¹

Potential disadvantages of TMR, which include size mismatch and the sacrifice of another nerve, should be kept in mind. However, it can be an option to consider in patients with previously failed neuroma surgeries, which is supported by a retrospective cohort study in this population.⁷ This case report shows successful TMR in a patient with a recurrent traumatic neuroma of the sural nerve after resection and capping of the distal nerve end. As postoperative MRI in our patient shows, however, TMR may not be without clinical consequence. More research is needed to further investigate this technique in nonamputee cases before wide application of the technique at various locations in the body using different target motor branches.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: de Ruyter, van Opijnen. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: de Ruyter, van Opijnen. Critically revising the article: de Ruyter, Hazelbag. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: de Ruyter. Administrative/technical/material support: van Opijnen, Hazelbag. Study supervision: de Ruyter.

Correspondence

Godard C. W. de Ruyter: Haaglanden Medical Center, The Hague, The Netherlands. g.de.ruyter@haaglandenmc.nl.