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IDEAS AND INNOVATIONS

Hand/Peripheral Nerve

Reset Neurectomy for Cutaneous Nerve Injuries

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Summary: Diffuse cutaneous nerve injuries, often caused by a crush mechanism, are challenging for the nerve surgeon. Discrete nerve transections and focal neuromas are easier to identify and have a more distinct treatment algorithm. Following crush injury to a noncritical sensory nerve, a successful local anesthetic block proximal to the injury may help determine the possibility of surgical intervention. In these cases, we describe a technique of "reset neurectomy" whereby a neurectomy is performed proximal to the zone of injury, and immediate repair or reconstruction (with or without a nerve graft) is performed. This technique may be useful in cases of diffuse, nontransection nerve injuries in which neuropathic pain is the primary symptom. *(Plast Reconstr Surg Glob Open 2021;9:e3401; doi: 10.1097/GOX.0000000000003401; Published online 15 February 2021.)*

INTRODUCTION

Diffuse, crush-type peripheral nerve injuries remain a challenging clinical problem for nerve surgeons. These nontransection nerve injuries result in pain and sensory disturbance with some preservation of function. Nerve injuries are often categorized by the Sunderland grading system,[1] where patients with grade I injuries are generally treated with expectant management, whereas patients with grade V injuries are most often offered nerve repair or reconstruction.

Incomplete nerve injuries (ie, grades II–IV) pose a different set of challenges, as it can be difficult to determine the relative degree of injury and therefore the expected amount of functional recovery. For these patients, decision-making is complex in the absence of nerve transection. Moreover, the amount of pain experienced by patients can vary widely for the same anatomic injury.

The treatment of neuropathic pain resulting from nontransection nerve injuries depends on the nature of the injury and the type of nerve involved. For larger mixed/motor nerves, complete nerve excision (neurectomy) is uncommonly performed because of concern for sacrificing functioning motor axons. Conversely, such injuries to cutaneous sensory nerves are viewed as distinct clinical entities with myriad treatment options, including neurolysis alone, nerve decompression with provision of a protective barrier (ie, wrap), autologous flap coverage, nerve excision and burial of the proximal nerve stump, relocation nerve grafting, targeted muscle reinnervation, or regenerative peripheral nerve interfaces.[2–8]

In this article we describe a novel technique for the treatment of crush, nontransection nerve injuries, hereafter referred to as "reset neurectomy" (RN). This technique removes the afferent pain signaling and allows directed nerve regeneration toward the native distal target.

DIAGNOSTIC WORKUP

Once the injured cutaneous nerve has been identified based on patient history and physical examination, a confirmatory local anesthetic nerve block is performed in the office using lidocaine/bupivacaine proximal to the site of pain. If the nerve block is successful in pain mitigation, surgical intervention is considered. Before discussion of surgical intervention, a course of nonoperative treatment is attempted consisting of desensitization, physical and/or occupational therapy, and neuropathic pharmacotherapy.

RN SURGICAL TECHNIQUE

RN involves transection of the affected nerve at a location proximal to the painful area with immediate coaptation to its distal nerve segment. This serves to remove the noxious afferent signals from the painful nerve and to promote directed nerve regeneration through the residual biologic scaffold of the distal nerve segment (Fig. 1).

When planning RN, one must first identify a point proximal to the area of nerve injury that is accessible and will allow for neurectomy and repair (with or without interposition auto- or allograft). This is often performed at the site of the diagnostic local anesthetic block. It is preferable

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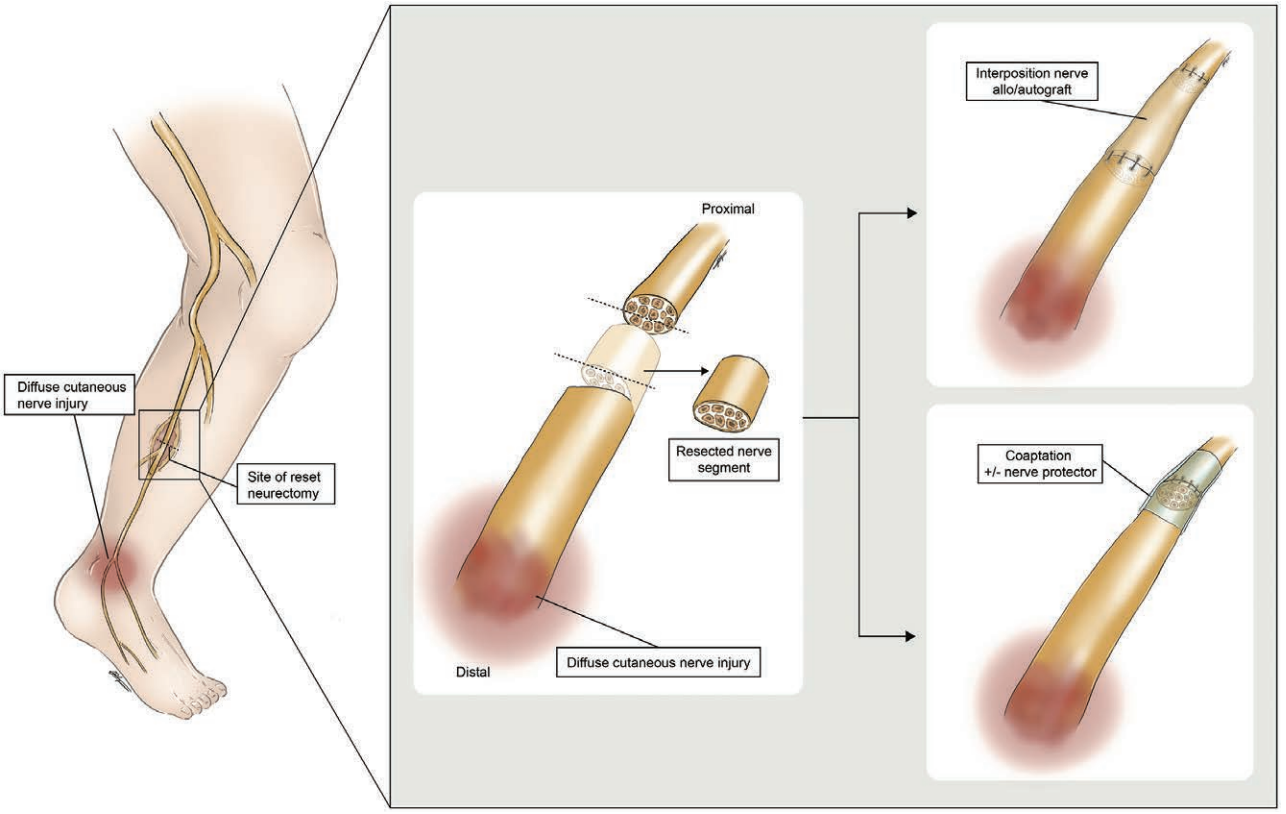

Fig. 1. RN is performed proximal to the area of pain, demonstrated here for the superficial peroneal nerve.

Fig. 2. Location of neuropathic pain and numbness; planned incision for RN.

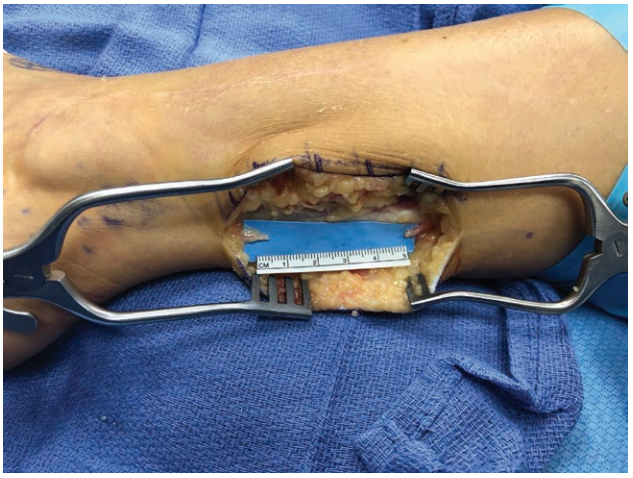

Fig. 3. Photograph showing 5-cm neurectomy of the sural nerve.

that the selected area also contains supple, well-vascularized soft tissue without scar or surgical trauma.

Intraoperatively, the involved nerve is isolated and a small segmental neurectomy is performed, varying between 5 mm and 50 mm. A direct primary coaptation may be used if the resected nerve segment is small. One may also consider an interposition nerve allograft or segmental autograft (which could be utilized/harvested from the same nerve during the neurectomy), to help further control the speed of nerve regeneration. Postoperatively, the patient's extremity is protected and activities are resumed in 2–3 weeks.

CASE ILLUSTRATION

A 24-year-old woman presented with a history of crush injury to her ankle, resulting in a fibular fracture and neuropathic pain on the lateral foot and ankle. She underwent fixation of her fracture by an orthopedic surgeon but had persistent diffuse neuropathic pain (Fig. 2).

Fig. 4. Photograph displaying nerve reconstruction with a 5-cm nerve allograft.

Diagnostic local anesthetic injection of her sural nerve in the middle/distal third of her leg provided near-complete pain relief. RN with interposition allograft was performed at the mid-distal leg (Figs. 3 and 4).

Postoperatively, the patient had nearly immediate relief of her pain and expected dermatomal numbness in the sural nerve distribution. Multi-modal therapy, including non-narcotic neuropathic pain medication and desensitization, was continued. At 1 year after surgery, she exhibited protective sensation in her extremity without pain or hypersensitivity (rated at 6/10).

DISCUSSION

Crush-type nerve injuries and those without obvious end-neuroma or neuroma-in-continuity can be difficult to treat, as conservative measures may fail and traditional surgical options most commonly involve nerve ablation without the potential for return of distal sensation. For these patients, the optimal conceptual solution involves removal of the painful, injured nerve segment with subsequent nerve reconstruction to allow for distal nerve regeneration. However, in many crush nerve injuries, it is difficult to determine the exact location of injury, particularly if concomitant soft tissue injuries are present. As a result, determining the location for traditional neuroma resection and nerve reconstruction can be challenging.

RN may be suited for diffuse nerve injuries without demonstrable neuroma. By performing the neurectomy proximal to the site of pain, this technique allows the surgeon to achieve the overarching goals of treatment: amelioration of pain with possibility of distal nerve regeneration. Fundamentally, this removes afferent signals from the site of the injured nerve and provides a "runway" through which the nerve can regenerate. It is not clear how much of the nerve should be resected for this technique, and it is possible that a neurotomy alone might offer a similar benefit without the need to resect a segment of nerve.

One theoretical concern with this technique is the possibility of reinnervation through a distal injured nerve segment. Although this is plausible, there are at least 2 reasons why this does not seem to occur[1]: the axonal growth cone dissipates over a long segment of endoneurial tubes, thus lessening the axonal density at the distal target and[2] Wallerian degeneration likely disrupts the disorganized (ie, aberrant) channels of the terminal nerve end/neuroma and thus prevents recurrence of pain as the nerve regenerates.[9–11] Anytime a neurotomy is performed, there is a chance of worsening pain and/or neuroma formation; however, we believe that this risk can be mitigated by performing proper nerve repair outside the zone of injury with appropriate size match for the involved nerve.

This technique can be applied in a variety of clinical scenarios in which the affected nerve injury is in the distal extremity and the proximal "runway" is long. We believe that this technique is ideally suited for cutaneous nerve injuries in the lower extremity (eg, superficial peroneal, sural, saphenous) and upper extremity (eg, MABC, LABC, RSN). Although possible, we feel that it should be avoided in mixed, proximal nerve injuries with intact distal motor function and in patients with Type I CRPS. Further study is warranted to determine exact indications and outcomes of this procedure.

CONCLUSION

Reset neurotomy is a technique to address neuropathic pain originating from a cutaneous nerve without identifiable neuroma.

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