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IDEAS AND INNOVATIONS

Peripheral Nerve

Surgical Technique for Targeted Muscle Reinnervation in Knee Disarticulation Amputation for Nonambulatory Patients

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Summary: Chronic neuropathic pain following major limb amputation has historically been difficult to treat. In patients undergoing lower extremity amputation, "preemptive" targeted muscle reinnervation (TMR) nerve transfers may be performed concurrently with the amputation to help mitigate the risk of chronic neuropathic postoperative pain. Despite clinical studies demonstrating efficacy of TMR in lower extremity amputations, few procedural descriptions have been written, and none have been written regarding performing TMR at the knee disarticulation (KD) level of amputation. Although uncommonly utilized, the KD amputation has clear functional benefits over other levels of amputation for nonambulatory patients. As nonambulatory patients are also subject to the occurrence of chronic neuropathic postamputation pain, it stands to reason that the addition of TMR to KD surgery could be an improvement to standard techniques. In this report, we provide a technical description for concurrent TMR with KD and describe the rationale for its use. *(Plast Reconstr Surg Glob Open 2023; 11:e4801; doi: 10.1097/GOX.0000000000004801; Published online 13 February 2023.)*

INTRODUCTION

Knee disarticulation (KD), or through-knee amputation, is a relatively uncommon level of lower extremity amputation. Although subject to debate about its utility in ambulatory patients using a prosthetic, KD has nonetheless found an important role for patients who are unlikely to ambulate. Functional priorities in bedridden or wheelchair-using patients are optimization of independent sitting and transfers, and prevention of secondary complications. As compared to an above knee amputation, the longer resulting lever arm and preservation of adductor insertions provided by a KD amputation ease transfers, promote sitting stability, and promote independent mobility by providing a better counterbalance. The KD amputation is also preferable to the below knee amputation in nonambulatory patients, as it avoids the risk of knee flexion contracture and subsequent decubitus ulceration (eg, against the bed or chair) of the residual limb.[1]

However, traditional techniques for KD do not account for measures to prevent chronic postoperative neuropathic pain, which may occur whether or not the patient is ambulatory after an amputation. Chronic pain, including neuroma-mediated residual limb pain and phantom limb pain, affects up to 25% of patients undergoing major limb amputations.[2] Chronic neuropathic pain following major limb amputation has historically been difficult to treat, and may lead to decreased quality of life,[3] chronic opioid use,[4] and economic burdens.[5] Recently, targeted muscle reinnervation (TMR) nerve transfers performed concurrently at the time of lower extremity amputation have been demonstrated to reduce the incidence of chronic postoperative neuroma pain and phantom pain.[6,7] Despite clinical studies demonstrating the efficacy of TMR in lower extremity amputation, few procedural descriptions have been written.[8] In this report, we provide a technical description employable by a single surgeon for concurrent TMR with KD and describe the rationale for its use.

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SURGICAL TECHNIQUE

The technique is applicable in any patient requiring amputation of the lower limb below the knee, who is not expected to ambulate postoperatively. Tourniquet control is used unless contraindicated. The technique of amputation is standard: a semicircumferential incision is designed along the knee joint line, with a posterior myocutaneous flap extension including the two heads of the gastrocnemius. While incising the joint laterally, the surgeon must be cognizant of the location of the common peroneal nerve, and dissect it free to the level of the fibular neck in order to preserve length for transfer. The tibial nerve is separated from the popliteal vessels, and ligation of the popliteal artery is performed distal to the origin of the sural arteries. The distal specimen is then amputated and attention is turned to the nerve transfers. Anatomically, the tibial nerve naturally enters the popliteal space but the peroneal nerve is diverted superficially, posterior to the lateral gastrocnemius and soleus. Therefore, the common peroneal nerve is identified distally and tunneled proximally and subfascially underneath the head of the lateral gastrocnemius, and then delivered into the popliteal space (Fig. 1). (**See Video [online]**, which displays the surgical technique for TMR in KD surgery.) With the two nerves delivered into the popliteal space adjacent to the neurovascular pedicles of the gastrocnemius muscles, TMR is then accomplished by coapting the tibial nerve to the motor nerve of the medial gastrocnemius, and the common peroneal nerve to motor nerve of the lateral gastrocnemius head with 8-0 Nylon suture (Fig. 2). The femoral cartilage is decorticated to promote soft tissue adherence, but the condyles are not trimmed as the limb will not fit with a prosthesis. The posterior flap is then debulked as needed and closed (Fig. 3).

Takeaways

Question: Given high rates of neuropathic pain following amputation, how may targeted muscle reinnervation (TMR) be utilized to reduce symptomatic neuroma formation?

Findings: This protocol allows for TMR concurrent with knee disarticulation by coaptation of the tibial and peroneal nerves to the medial and lateral gastrocnemius heads.

Meaning: TMR concurrent with knee disarticulation is a simple technique that may be used by a single surgeon seeking to prevent symptomatic neuroma formation in a patient population highly prone to developing difficult to treat neuropathic pain.

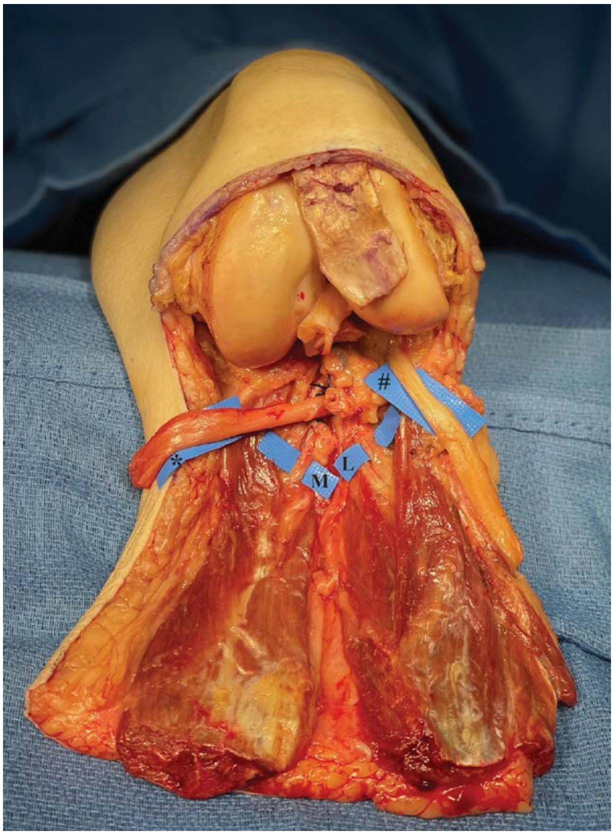

Fig. 1. Intraoperative view of a patient following KD and identification of the tibial nerve (*), peroneal nerve (#), and motor nerves to medial (M) and lateral (L) heads of the gastrocnemius muscle. The peroneal nerve has been tunneled from deep to superficial underneath the lateral head of gastrocnemius.

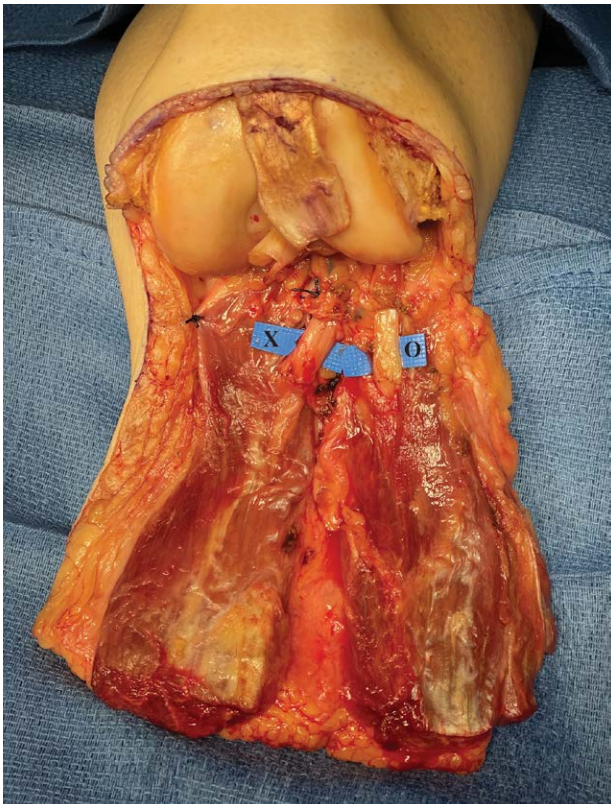

Fig. 2. TMR has been accomplished by coapting the tibial nerve to the motor nerve of the medial gastrocnemius (X) and peroneal nerve to the motor nerve of the lateral gastrocnemius (O). Coaptations are performed under loupe magnification with 8-0 Nylon suture, at the level of the motor nerve's penetration into the muscle.

Fig. 3. Postoperative view following the posterior flap closure.

DISCUSSION

Reports demonstrating that TMR shows significant efficacy in treating neuroma pain and phantom limb pain following lower extremity amputation describe that various techniques were used by individual surgeons, all sharing the general pattern of coapting a major mixed nerve to a smaller expendable motor nerve.[7] Because a wide variety of techniques and indications have all been described as successful,[9] it is presumed that the physiological mechanism of providing a denervated muscle target for an injured nerve to grow into, rather than the specific technique, is generally responsible for the outcome. This article is thus intended to be a technical guide to simplify adoption of TMR in KD surgery, and not an outcomes study. Alternative techniques, such as regenerative peripheral nerve interface, use a similar theory and may be considered as well.

However, experience with failed cases of TMR shows that certain considerations, such as placement of the coaptation site in an area away from pressure and avoidance of neural kinking, can be important in achieving good outcomes.[10] This technique attempts to account for these factors. The technique is recommended for nonambulatory patients, because it places the nerve coaptations at the most distal aspect of the residual limb. In the situation of weight bearing within a prosthetic socket, this would be an unfavorable location subject to mechanical pressure. However, in the nonambulatory patient, pressure is placed only on the posterior aspect of the limb when it is used for positioning. Tunneling the common peroneal nerve subfascially into the popliteal space prevents kinking of the nerve that would otherwise occur in its retrograde course to meet the lateral gastrocnemius motor nerve.

Other benefits of this technique are that it is simple, “macroscopic,” and only adds 15 minutes to operative time. Apart from tunneling the common peroneal nerve, the steps of the amputation itself are identical to a simple KD. Nerve stimulators are hardly required apart from verification of the recipient nerves; although the location of the nerves is anatomically constant, they must be distinctly identified and carefully separated from the vascular pedicles of the gastrocnemius muscles, as inadvertent injury to those vessels could affect the blood supply to the posterior myocutaneous flap.

CONCLUSIONS

The effectiveness of TMR in preventing symptomatic neuroma for patients with lower extremity amputation has been well demonstrated, but technical descriptions for performing TMR in KD surgery are lacking. This simple, reproducible approach to TMR at time of KD allows for efficient operative technique and an opportunity to minimize chronic neuropathic postoperative pain.

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