Mixed-Motor Sensory Nerves at Greater Risk for Refractory Neuropathic Pain Compared to Sensory Nerves Following Primary Targeted Muscle Reinnervation in Above Knee Amputations

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INTRODUCTION: By convention, delayed targeted muscle reinnervation (TMR) addresses all named sensory and mixed motor-sensory nerves in symptomatic patients to reduce neuroma associated pain versus unmasking previously asymptomatic nerves. However, in the acute setting following above knee amputation (AKA), it remains unclear which or if all named nerves should be prioritized for coaptation. We hypothesize that mapping refractory neuropathic pain patterns after primary TMR can identify the most excitable afferent nerves, helping refine surgical strategies that more efficiently mitigate pain.

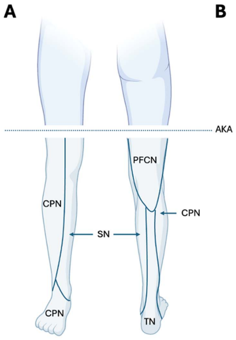
METHODS: We retrospectively reviewed all patients undergoing prophylactic TMR at the time of AKA at a single institution over 10 years. Of 22 patients, 19 had sufficient one-year follow-up. A standardized operative protocol was followed. A vertical posterior thigh incision exposed the sciatic nerve, which was dissected distally into the mixed motor-sensory tibial (TN) and common peroneal nerves (CPN) and coapted end-to-end to posterior compartment motor branches. Sensory saphenous (SN) and posterior femoral cutaneous nerves (PFCN) were transected and coapted to motor targets when feasible. We evaluated the incidence of refractory neuropathic pain—intractable pain in the amputated limb's distribution persisting beyond six months postoperatively. We localized refractory neuropathic pain by mapping patient reports of phantom limb pain recorded in clinical encounter notes to cutaneous nerve distributions and reviewing imaging of symptomatic neuromas (Figure 1). Refractory pain incidence between nerve groups was compared via chi-square analysis. All significance testing was two-tailed with a threshold of $p<0.05$.

RESULTS: Among 76 transected nerves (38 mixed, 38 sensory), refractory phantom limb pain was more common in mixed motor-sensory nerves, with 15/38 (39.5%) exhibiting pain compared to 7/38 (18.4%) of sensory nerves ($p=0.043$). The CPN and TN accounted for most cases, with pain reported in 8/19 (42.1%) and 7/19 (36.8%) nerves, respectively. Among sensory nerves, pain was observed in the SN in 5/19 (26.3%) cases and PFCN in 2/19 (10.5%) cases. Among mixed motor-sensory coaptations, [CPN, TN]-biceps femoris exhibited the greatest pain incidence, while CPN-semitendinosus and TN-semimembranosus showed lower rates. Sensory nerves had consistently low pain incidence regardless of coaptation.

DISCUSSION AND CONCLUSION:

This retrospective review of 19 patients undergoing prophylactic TMR at the time of AKA with one-year follow-up demonstrates that refractory neuropathic pain was most frequently localized to mixed motor-sensory nerves, particularly the common peroneal and tibial nerves. Among recipients of coaptations involving mixed motor-sensory donors, the motor branch to the biceps femoris exhibited the most pronounced donor-recipient size mismatch and was associated with the highest incidence of refractory pain. These findings suggest that in mixed motor-sensory nerves, the combination of donor-recipient size mismatch and the inherently greater volume of afferent and efferent fibers may predispose to persistent pain. This underscores the need to refine surgical technique in these settings, particularly through improved donor nerve distribution strategies to better accommodate the structural complexity and fiber load of mixed nerves.

A



B

Description of neuropathic pain	Neural localization
Painful phantom sensation of knee bending	TN, CPN
Phantom limb pain in sciatic distribution; positive Tinel at medial stump scar	TN, CPN, SN
Tingling of foot when the back of thigh is rubbed; occasionally feels as if someone steps on toes or kicks calf; phantom pain mostly to the bottom of foot/ankle; small sciatic stump neuroma	TN
Phantom limb pain, entire foot	TN, CPN, SN
Phantom limb pain over top of foot	CPN
Pain shooting just below posterior thigh	PFCN
Pain shooting down entire leg	TN, CPN, PFCN, SN
Complained of phantom limb pain, had a spinal cord stimulator placed at L4 to L5 and symptoms improved	TN, CPN, SN
Distal sciatic stump neuroma; severe phantom limb pain in foot	TN, CPN
Excruciating phantom pain at knee	CPN, SN

Figure 1. Localization of refractory neuropathic pain. **A)** Cutaneous nerve distribution of phantom limb following above knee amputation (AKA). **B)** Descriptions of refractory pain in patient cases (TN = tibial nerve, CPN = common peroneal nerve, PFCN = posterior femoral cutaneous nerve, SN = saphenous nerve).

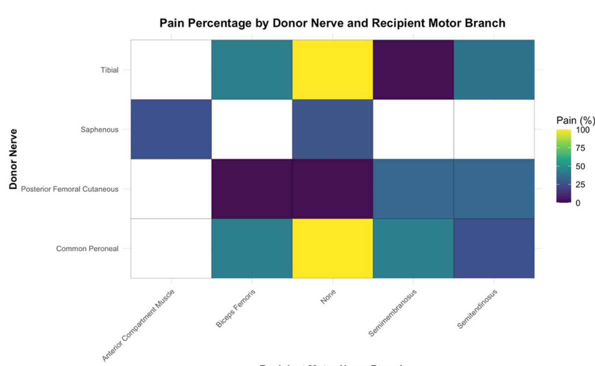


Figure 2. Heatmap of refractory neuropathic pain incidence by donor and recipient coaptation combinations. White cells reflect an absence of a given coaptation combination in the dataset.