Comparative efficacies of TMR vs RPNI in reducing phantom limb and neuroma pain for patients with BKAs

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Background

Chronic pain is a common and debilitating complication following lower limb amputation. Neuroma formation and phantom limb pain (PLP) can significantly impact patients' quality of life, with up to 80% of amputees reporting chronic pain. Two surgical innovations, Targeted Muscle Reinnervation (TMR) and Regenerative Peripheral Nerve Interface (RPNI), have emerged as promising techniques for mitigating these outcomes.

This project compares outcomes of TMR and RPNI in below-knee amputees, focusing on phantom limb pain, neuroma pain, and overall pain interference. Patient-reported outcomes were measured using the PROMIS Pain Interference 6b along with surveys on prosthetic use and satisfaction. The goal is to provide early insights into how these techniques impact quality of life, providing guidance in clinical decision-making for surgical treatment of patients undergoing amputations.

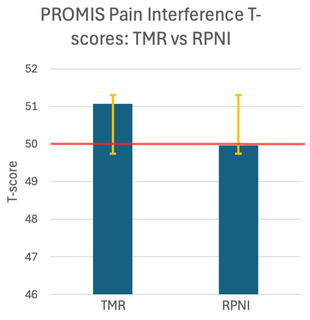
TMR	RPNI
Transfer of transected peripheral nerves to motor nerve branches of nearby muscles	Implantation of transected nerve endings into free muscle grafts without motor nerve coaptation
Redirects aberrant nerve signals to prevent pain	Provides a physiologic target for nerve regeneration
Requires available motor nerve branches near amputation site	Requires availability of small free muscle grafts
Potential added benefit for myoelectric prosthetic control	Primarily focused on pain reduction, not prosthetic control

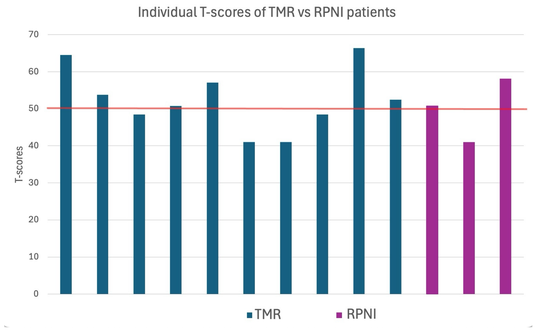
Methods

		In the past 7 days… Not at all	A little bit	Somewhat	Quite a bit	Very much
PAININ3	How much did pain interfere with your enjoyment of life?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ8	How much did pain interfere with your ability to concentrate?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ9	How much did pain interfere with your day to day activities?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ10	How much did pain interfere with your enjoyment of recreational activities?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PAININ14	How much did pain interfere with doing your tasks away from home (e.g., getting groceries, running errands)?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
	In the past 7 days…	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
PAININ26	How often did pain keep you from socializing with others?.....	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

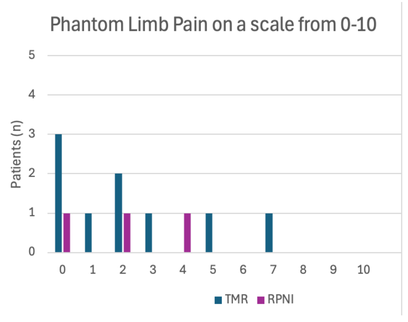
Pain interference was assessed using the **PROMIS Pain Interference Short Form 6b**, a validated patient-reported outcome measure that yields standardized T-scores (mean = 50, SD = 10) benchmarked to the U.S. general population. Additionally, questions involving pain scale, prosthetic use, painkiller use, and overall satisfaction were asked.

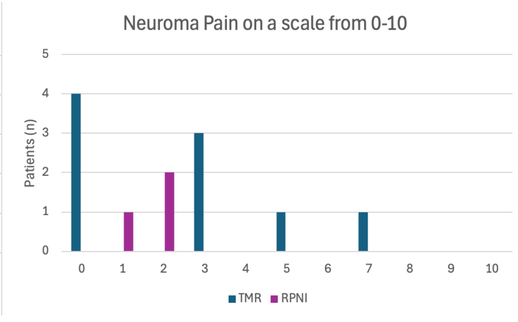
Results





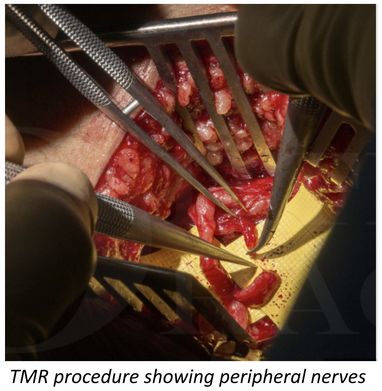
PROMIS scores: TMR patients had a mean T-score of **52.4 ± 8.6 (SD)**, with values ranging from 41.0 to 66.4. RPNI patients had a mean T-score of **49.9 ± 8.6 (SD)**, ranging from 41 to 58.1. Both groups scored near the PROMIS population mean of **T = 50**, suggesting that pain interference was not substantially elevated compared to the general U.S. population.





Pain Scale: On a 0–10 scale, average phantom limb pain was **2.28** in TMR patients and **2.0** in RPNI patients, indicating low levels of residual phantom pain in both groups. For neuroma pain, average scores were **1.0** in TMR patients and **2.3** in RPNI patients. Overall, both surgical techniques were associated with low pain ratings, with no clinically meaningful differences between groups.

RPNI procedure done for a large neuroma of the sciatic nerve.



TMR procedure showing peripheral nerves being attached to nearby motor nerves.

Conclusions

1. TMR and RPNI are equally effective at improving pain.
2. TMR and RPNI both restore pain interference levels to normal.
3. TMR and RPNI both average low scores on a scale from 0-10 for neuroma and phantom limb pain
4. 100% of patients reported that they would undergo the procedure again, reflecting very high satisfaction rates.

Future studies should expand the patient population from those who received BKAs to include patients who received AKAs and upper extremity amputations as well. Because limb use and activity level vary by amputation type, outcome levels for TMR and RPNI may differ. In addition, building larger, multicenter cohorts will allow for greater power and more definitive comparisons to guide surgical decision-making.

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