

CORR Insights®: Targeted Muscle Reinnervation Improves Residual Limb Pain, Phantom Limb Pain, and Limb Function: A Prospective Study of 33 Major Limb Amputees

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Where Are We Now?

Targeted muscle reinnervation (TMR) was pioneered by Todd Kuiken MD, PhD as a means of permitting real-time myoelectric control of upper extremity prostheses [2, 3]. Prior to TMR, functional improvement of amputation was primarily achieved with myodesis, adequate soft-tissue closure, prosthetic design, and good

postsurgical therapy. But with TMR, microsurgical reinnervation of non-functional muscles or redundant motor nerves can potentially improve function proactively at the index procedure.

Surgeons who use TMR techniques have also learned that prevention and minimization of phantom limb pain and pain arising from neuromas could be addressed at the time of amputation. This is an elegant extension of giving the surgically transected nerve “some-where to go and something to do”.

For patients with amputations, TMR techniques can now be applied up front to minimize neuropathic pain and phantom limb pain, to try to minimize the frequency with medications and surgical treatment of neuropathic pain or phantom limb pain after amputation come into the picture. Symptomatic postamputation neuroma has an overall incidence of 4.17% [5], but phantom limb pain after amputation can occur in 50% of patients [1]. With phantom limb pain being so common after amputation surgery, it is hard to imagine organizing resources at many hospitals for amputation patients who would get long-term benefits from TMR.

The current study by Mioton and colleagues [4] shows the benefit of TMR

in terms of addressing pain after amputation, and so it can be extrapolated that as we improve pain, function will improve as well. For those with amputations, TMR’s primary benefit is and has always been functional improvement.

Where Do We Need To Go?

Considering that most amputations are done by surgeons who may not have training and/or competence in microsurgery of nerves, we need to determine whether there are alternative approaches that can replicate the success of TMR without utilizing microsurgical techniques.

This study raises many additional questions regarding indications, outcomes, research studies, and clinical trials. Specifically, can collagen nerve caps, other surgical techniques, and/or novel products replicate the success level of TMR? Even for those with microsurgical skills, can those skills also translate to competence with nerve microsurgery? For example, can a vascular surgeon who has microsurgical skills also perform microsurgical nerve surgery like TMR? If local TMR expertise is available, which amputations need to be prioritized for this technique as hospital-based TMR multidisciplinary surgical teams are a limited resource? If TMR is indicated, can an amputation be done at the

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referring facility? Can TMR be performed in delayed fashion with equal success as TMR done at the time of amputation?

Theoretically, TMR can benefit many patients, but consideration has to be given to surgical learning curve, additional anesthesia time to perform TMR, and availability of TMR microsurgical skill set.

How Do We Get There?

Fortunately (actually, unfortunately), the number of surgeons interested in TMR is limited, and so this may be the opportunity to engage like-minded surgeons to prioritize key research questions for multicentric clinical study groups. Like the hub and spoke model, each study site then has the potential to become a regional center of excellence for TMR. Additionally, developing these focused specialty groups within the graduate medical

education umbrella will ensure that the message of TMR continues to grow and disseminate for the benefit of patients with amputations.

For me, nuances of specialized surgical techniques are often identified or elucidated during face to face interactions at meetings or other gatherings of surgeons with a focused interest, and in the post-coronavirus-2019 era, will distance learning provide similar opportunities to develop relationships and intellectual curiosity? Regardless of the healthcare system issues associated with TMR, kudos to the authors of this study [4] who have presented information that is thought provoking in that patients with chronic post-amputation neuropathic pain now have an opportunity to live life without pain and without medications to treat their pain.

References

1. Bone M, Critchley P, Buggy DJ. Gabapentin in postamputation phantom limb pain: a randomized, double-blind, placebo-controlled, cross-over study. *Reg Anesth Pain Med.* 2002;27:481-486.
2. Kuiken TA, Dumanian GA, Lipschutz RD, Miller LA, Stubblefield KA. The use of targeted muscle reinnervation for improved myoelectric prosthesis control in a bilateral shoulder disarticulation amputee. *Prosthet Orthot Int.* 2004;28:245-253.
3. Kuiken TA, Li G, Lock BA, Lipschutz RD, Miller LA, Stubblefield KA, Englehart KB. Targeted muscle reinnervation for real-time myoelectric control of multifunction artificial arms. *JAMA.* 2009;301:619-628.
4. Mioton LM, Dumanian GA, Shah N, Qiu CS, Ertl WJ, Potter BK, Souza JM, Valerio IL, Ko JH, Jordan SW. Targeted muscle reinnervation improves residual limb pain, phantom limb pain, and limb function: A prospective study of 33 major limb amputees. *Clin Orthop Relat Res.* [Published online May 20, 2020]. DOI: [10.1097/CORR.0000000000001323](https://doi.org/10.1097/CORR.0000000000001323).
5. Penna A, Konstantatos AH, Cranwell W, Paul E, Bruscano-Raiola FR. Incidence and associations of painful neuroma in a contemporary cohort of lower-limb amputees. *ANZ J Surg.* 2018;88:491-496.