

Targeted Muscle Reinnervation (TMR)

A Procedure for Upper and Lower Extremity Amputations

I have healed from an amputation. Why do I still have pain?

Pain following an amputation is common. The main cause of pain after an amputation is **neuropathic pain**, which refers to pain that originates from traumatized nerves.

Amputations require cutting nerves at the level of the amputation. Neuropathic pain occurs when these severed nerves attempt to regenerate and repair. Since the other end of these severed nerves has been lost in the amputated part, the regenerating nerves in the residual limb have nowhere to bridge across to and often end up forming an exquisitely tender lump of disorganized nerve tissue known as a **neuroma**.

In addition, the nerves of residual limbs can also send 'false' messages to your brain, giving you the sensation that the amputated limb is still present. This is called **phantom pain**.

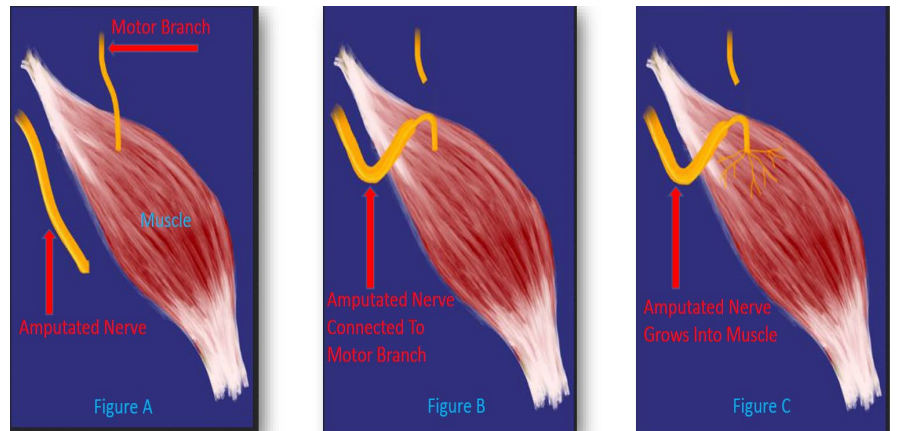


Figure: Targeted Muscle Reinnervation Procedure
Figure A: Amputated severed nerve, nearby redundant nerve branch to muscle (motor branch).
Figure B: Amputated nerve surgically connected to redundant motor branch.
Figure C: Amputated nerve grows into motor branch.

What is TMR and how can it help?

Targeted muscle re-innervation (TMR) is a technique used to treat nerves in the residual limb. The procedure involves connecting the severed nerves to nearby redundant nerve branches that supply muscles also known as motor branches (Figure A, B). TMR allows the severed nerve to grow into these motor branches which satisfies the nerve by giving them "somewhere to go and something to do." In this manner, TMR helps prevent the formation of painful neuromas as well as phantom limb pain (Figure C).

Hand, Upper Extremity, and Microsurgery

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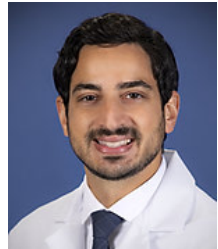
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What's the evidence for TMR?

The landmark study showing the effectiveness of TMR for lower limb amputation neuroma pain and 'phantom' limb pain was published in 2019 by Dumanian and colleagues¹. Using a numeric rating scale of 0-10 (10 being the worst), this randomized prospective controlled trial demonstrated that patients who underwent TMR experienced a **decrease** of 3.2 points in 'phantom pain' and 2.9-point **decrease** in neuroma related pain at one year follow-up. Similar results were again reported by Dr. Dumanian's group in 2020 with another group of 33 patients who underwent TMR following amputation of the lower or upper extremity². Since then, multiple studies have demonstrated significant improvement in pain after TMR for both upper and lower extremity amputations^{3,4}.

When is TMR procedure performed?

TMR can be carried out at the time of the initial amputation, however we feel it is better for patients to have it done later as a secondary standalone procedure since:

1. It allows for the amputation wounds to heal and allows the patient to recover from the trauma of limb loss.
2. TMR is a smaller procedure performed via a smaller separate incision.

What does the procedure involve?

The surgery involves general anesthesia, making an incision, identifying the main nerves in the residual limb that were severed during the amputation, and re-connecting those nerves to the nearby motor branches. The wounds are then closed with dissolving stitches and a compression dressing is placed to reduce swelling and pain.

What are the risks of the procedure?

There is a risk of temporary or possibly permanent numbness around the stump, requiring the patient to check their skin regularly for signs of damage and infection. While most patients will experience a major improvement in pain after surgery, a very small number of patients may experience worsened pain following surgery.

Major risks associated with performing surgery on any limb include deep vein thrombosis and pulmonary embolism, which are generally managed with blood-thinning medication. Bleeding and infection are minor risks associated with TMR surgery.

What happens after the procedure?

After the procedure, the patient can expect a one-night hospital stay. We recommend elevating the limb to reduce pain and swelling for 5-7 days after the procedure. It is common for patients to experience higher post-operative pain for up to one month after the operation. This is because the reconnected nerves need the time to heal. Improvement in phantom pain and neuroma pain usually takes place at least 3-6 months after surgery.

References:

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