

Pronator Quadratus: A Preferable Recipient for Targeted Muscle Reinnervation of Neuromas in the Hand

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Summary: Targeted muscle reinnervation (TMR) has emerged as a useful solution to the problem of painful neuromas and is increasingly being applied in many clinical circumstances. Relatively little has been written about TMR for painful neuromas of the hand, and what has been written describes use of the intrinsic muscles as recipients for the nerve transfer. Except in cases of amputation, intrinsic muscle sacrifice carries morbidity. Furthermore, TMR to intrinsic muscles will place the nerve coaptation in areas subject to pressure with loading of the palm. For these reasons, the pronator quadratus may be a preferable target muscle when performing TMR for painful neuromas of the hand. In this report, we describe the rationale for its use and demonstrate the surgical technique and outcomes with case examples. (*Plast Reconstr Surg Glob Open* 2022;10:e4640; doi: 10.1097/GOX.0000000000004640; Published online 18 November 2022.)

INTRODUCTION

Symptomatic neuromas are a common, painful complication for patients with peripheral nerve injuries. Multiple surgical and nonsurgical treatment modalities have been described,¹ but surgery has been shown to be effective in improving hand function and quality of life.^{2,3} Targeted muscle reinnervation (TMR) is a surgical treatment involving transfer of a sensory or mixed nerve to the motor nerve of a denervated target muscle. TMR has shown promising results and is being increasingly applied to treatment of painful neuromas in a variety of circumstances.⁴ This IRB exempt clinical report highlights the utility of the pronator quadratus (PQ) as a TMR target in complex or refractory cases, and discusses the benefits of selecting this muscle as a target versus the intrinsic muscles of the hand.

CASE PRESENTATIONS

Case 1

A 56-year-old woman presented with painful neuromas of the left palm related to a ring avulsion injury and ring finger (RF) revision amputation 10 years before presentation. She complained of pain and weakness with grasp,

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This study was approved by an independent IRB.

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and small objects falling through the amputation site. Following the original amputation, the patient had undergone seven separate excision procedures for symptomatic digital neuromas. Examination demonstrated a positive Tinel sign at the mid-palm radiating to the RF stump as well as to the tip of the middle finger (MF). Hypesthesia and allodynia of the ulnar aspect of the MF were also noted, indicating injury of the common digital nerve to the third webspace with one of the prior procedures.

She was treated with ray amputation of the RF, intra-neural neurolysis of the RF digital nerves from the median and ulnar nerves to a level proximal to the wrist crease, TMR of the RF digital nerves to the PQ, and vascularized anterior interosseous nerve (AIN) nerve graft to reconstruct a 7-cm gap of the MF ulnar digital nerve in a reoperative field (Fig. 1). (See Video [online], which shows a detailed case presentation of patient 1, including indications and long-term outcomes.)

She was followed up for 16 months and regained normal grip, range of motion, and pronation. She had no recurrence of palmar neuroma pain. She had no dysesthesias, weakness, or other nerve dysfunction related to the extensive intraneural dissections of the median and ulnar nerves. Subjective sensation to light touch had returned throughout the MF ulnar digital nerve distribution. She had mild tenderness over the PQ with deep palpation, but this did not limit her function. (See Video [online], which shows a detailed case presentation of patient 1, including the surgical technique and long-term outcomes.)

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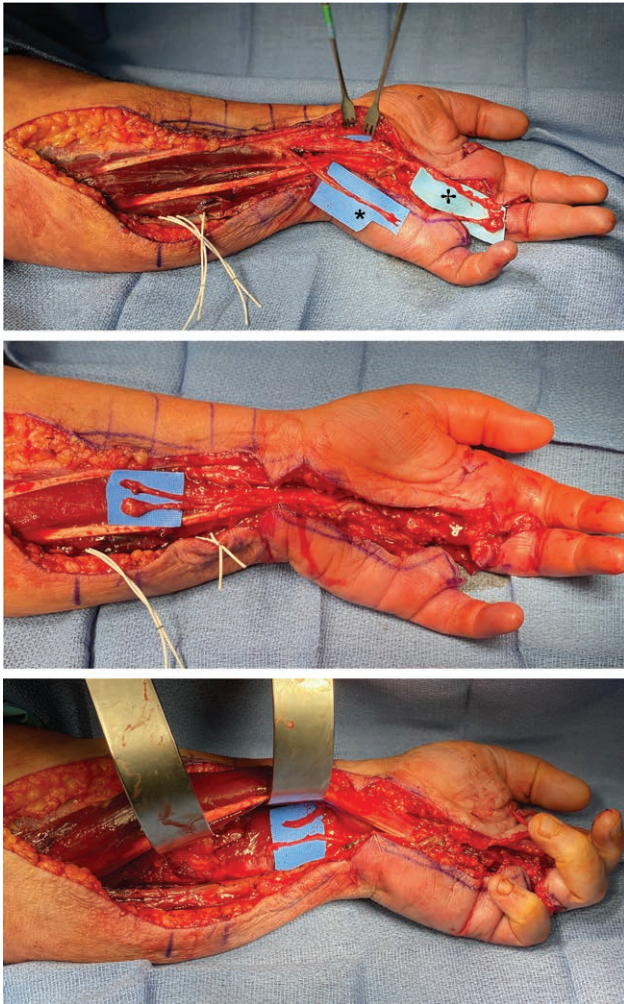


Fig. 1. Intraoperative view of patient 1. A, The RF RDN and MF UDN are involved in a tangle of scar tissue or neuroma in continuity (*). The RF UDN (*) has been neurolysed away from the ulnar nerve proper to a level proximal to the wrist crease. B, Neuromas of RF RDN and UDN are neurolysed separately from the median and ulnar nerves and transposed to the distal forearm without tension. C, After neurolysis, neuroma excision, and deep transposition, the RF digital nerves reach the PQ target without tension. RDN, radial digital nerve; UDN, ulnar digital nerve.

Case 2

A 55-year-old woman presented with complex regional pain syndrome of the right hand and wrist following a comminuted distal radius fracture with a complicated recovery including ORIF, prolonged casting, fracture subsidence, and tenolysis of multiple flexor tendons, including the palmaris longus. Grip strength and range of motion were diminished. She was diagnosed with untreated carpal tunnel syndrome, radial sensory nerve compression, and a neuroma of the palmar cutaneous branch of the median nerve (PCBMN).

She underwent carpal tunnel release, neuroma excision, TMR of the PCBMN to the PQ (Fig. 2), radial sensory nerve decompression, wrist denervation and capsulotomy, and flexor tenolysis. She was followed up for 7 weeks,

Takeaways

Question: What alternatives to intrinsic hand muscle sacrifice exist in targeted muscle reinnervation (TMR) for complicated hand or digital neuromas?

Findings: Based on two cases, this description for TMR to the pronator quadratus (PQ) resolved neuropathic pain and restored grip. Digital nerves reached the PQ without tension after neurolysis from major nerves.

Meaning: Targeting PQ for TMR benefits from a muscle location deep and proximal to areas of grip and loading of the palm, a redundant function, and availability of the anterior interosseous nerve for grafting when concomitant reconstruction is indicated.

at which point her pain had resolved and she regained unimpaired grasp. Aside from the expected numbness over the PCBMN distribution, there was no neuropathic dysfunction.

DISCUSSION

TMR is an effective method for management of neuromas, although motor nerve dissection and sacrifice carries additional surgical morbidity compared to simpler techniques. In complex and functionally debilitating cases such as those with complex regional pain syndrome or recurrent neuromas affecting grip, the additional morbidity may be justifiable. Because a wide variety of techniques and indications have all been described as successful,⁵ 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 responsible for the outcome.

However, no surgical procedure is without failures, and re-exploration of failed TMR cases has demonstrated painful neuroma formation at the nerve coaptation site despite successful muscle reinnervation.⁶ Several pitfalls have been identified in cases of failed TMR, including placement of the coaptation in areas subject to frequent mechanical pressure; a finding that aligns well with traditional principles of neuroma management.

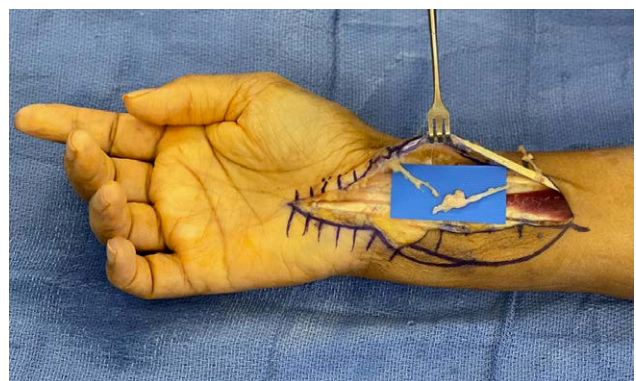


Fig. 2. Intraoperative view of patient 2. A neuroma of the palmar cutaneous nerve was identified and TMR was performed to the PQ muscle.

Thus, target choice is relevant, and particularly pertinent in the hand. Prior publications regarding TMR for symptomatic neuromas in the hand have described use of the interossei and lumbricals as muscle targets.⁷⁻⁹ These muscles have several characteristics limiting their utility. Their use is limited to cases of amputation as none are functionally expendable without some effect on finger function, and, critically, they are all located in areas subject to pressure with loading of the palm.

In contrast to the intrinsic muscles of the hand, the PQ provides a target that is both functionally expendable as well as located in a deep, non load-bearing area. This report demonstrates that even the most distal nerves of the hand, for example, the digital nerves, can be separately neurolysed from their respective major nerves proximally enough to reach the PQ without tension. Transection of the AIN, necessary to accomplish TMR to the PQ, makes the distal AIN available for use as a traditional or vascularized nerve graft. The AIN has a caliber suitable for reconstruction of the small nerves of the hand. This may be useful in situations such as in case 1 where an injury pattern has created the need for neuroma management as well as nerve reconstruction.

Drawbacks of this surgery include the need for additional exposure, dissection, and skin scarring compared to that needed for the hand intrinsic muscle targets. Additionally, expertise with intraneural dissection is needed. While skin scarring is generally well accepted by chronic pain patients, the additional surgical effort, morbidity, and risk (eg, of intraneural dissection) must be weighed before proceeding. Assessment of patient outcomes in these illustrative cases is limited by short follow-up times and subjective measurements of nerve function, including light touch. We therefore recommend this technique only for cases deemed refractory or sufficiently complex by the surgeon.

CONCLUSIONS

Numerous studies have demonstrated the efficacy of TMR for treatment of symptomatic neuromas. Using PQ as a target for neuromas of the hand and digits avoids the morbidity associated with sacrificing hand intrinsic

muscles and the potential pitfall of placing nerve coaptations in areas subject to frequent pressure. An added benefit is the availability of the AIN as nerve graft when needed. Despite its location proximal to the wrist crease, even digital neuromas can be transferred to it without tension. PQ should be considered as a TMR target for patients with recurrent or difficult to treat neuromas of the hand and digits.

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