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IDEAS AND INNOVATIONS

Peripheral Nerve

Radial Nerve Fascicular Transfer Preserving Long Head through Anterior Incision for Transhumeral Targeted Muscle Reinnervation

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Summary: New developments in targeted muscle reinnervation promise better options for treatment of neuropathic pain and improved prosthetic control. For transhumeral amputations, the traditional approach involves an anterior incision to access the median and ulnar nerves and a second posterior incision to access the radial nerve. This is necessitated as exposure of motor branches of the radial nerve distal to the branch to the long head of the triceps is difficult from the anterior approach. Herein, we describe a technique for transferring the radial nerve proper distal to the long head branch to a motor branch to the medial or lateral head of the triceps through internal neurolysis and fascicular transfer. This allows all surgical steps to be performed through a single incision while preserving native motor branches to the biceps and triceps muscles. *(Plast Reconstr Surg Glob Open 2022;10:e4483; doi: 10.1097/GOX.0000000000004483; Published online 15 August 2022.)*

INTRODUCTION

Targeted muscle reinnervation (TMR) in amputees allows intuitive myoelectric control of limb prostheses and reduces postamputation pain.[1,2] The technique for transhumeral amputations was first reported by O'Shaughnessy et al[3] and relied on a two-incision approach: an anterior incision for exposure of the median and ulnar nerves and a posterior incision for exposure of the radial nerve. The posterior incision allowed exposure of the radial nerve branch to the lateral head of the triceps, which was the recommended motor target[3] for the radial nerve. Maintenance of native elbow flexion and extension signals through preservation of a motor branch innervating the biceps and radial nerve innervation of the long head of the triceps is essential for prosthetic control, in addition to creating new "hand open" and "hand close" signals.[4]

A single-incision anterior approach was later described by Daly et al,[5] where the radial nerve was transferred to a motor branch to the long or lateral head of the triceps. Advantages of the single-incision approach include obviation of the need for repositioning to a prone position or difficult access of the posterior arm, which often requires an assistant. However, sacrifice of all native triceps innervation, which is necessitated when the radial nerve is transferred to the branch to the long head, is not ideal when the patient is a candidate for an advanced myoelectric prosthesis.

The radial nerve branch to the long head of the triceps is its most proximal branch and originates in the axilla, running over the latissimus dorsi tendon.[6,7] This branch is always accessible through an axillary or medial arm incision when supine. However, exposure of the branches to the medial or lateral head of the triceps is more difficult from the anterior approach.[8] Here, we report the use of internal neurolysis and targeted fascicular dissection to identify a motor target for the radial nerve distally, allowing preservation of the branch to the long head in all instances when using a single-incision approach for transhumeral TMR.

CASE EXAMPLE AND SURGICAL TECHNIQUE

A 73-year-old woman with a history of poorly controlled type-2 diabetes, hypertension, and hyperlipidemia sustained a traumatic elbow disarticulation of the left arm 26 years before presentation. She had pain localized to her stump, consistent with neuroma pain, which had

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Received for publication May 2, 2022; accepted June 30, 2022.

This work has not been presented at a local, regional, national, or international conference, and no parts of it are published or being considered for publication.

DOI: 10.1097/GOX.0000000000004483

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

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worsened in the months before presentation. In addition, she had phantom pain relating to feeling her fingers clenched in a fist. On examination, she had a localized area of tenderness at the end of the stump, and magnetic resonance imaging of the left arm showed end neuromas of the median, ulnar, and radial nerves. After discussing treatment options, we decided to proceed with shortening to a formal transhumeral amputation and TMR to address her neuromas.

A single medial-arm incision was used for exposure over the medial intermuscular septum, between the biceps and triceps. Dissection was carried down to expose the median, ulnar, radial, and musculocutaneous nerves and their branches as previously described.[3,5]

The radial nerve was identified on the posteromedial arm, along with the branch to the long head of the triceps muscle (Fig. 1). The other neurovascular structures were safely retracted anteriorly using a self-retaining retractor. There were no other branches visible coming off the radial nerve distal to the branch to the long head of the triceps. Internal neurolysis was then performed to isolate the motor fascicle to the medial head of the triceps on the posterior surface of the radial nerve. Video 1 shows sequential stimulation with a nerve stimulator on 0.5 mA of the (1) long head branch, (2) neurolysed radial nerve fascicle to the medial head of the triceps, and (3) radial nerve proper, with resultant contraction of the lateral head of the triceps. (**See Video 1 [online],** which displays the stimulation of radial nerve and its branches before nerve transfer.)

The radial nerve was then transferred to the neurolysed radial nerve fascicle to the medial head of the triceps muscle through an end-to-end coaptation in a standard fashion (Fig. 2). Video 2 shows conduction across the coaptation site with stimulation on 0.5 mA following radial nerve TMR to the medial head of the triceps. (**See Video 2 [online]**, which depicts postradial nerve TMR nerve stimulation.) Then, the median nerve was transferred to the musculocutaneous nerve branch to the long head of the biceps and the ulnar nerve transferred to the branch to the brachialis. A dry sterile dressing was placed, which was removed when the patient was seen in clinic 1 week postoperatively. No immobilization was used. As assessed through the numerical rating scale, the patient's worst residual limb pain and phantom limb pain decreased from 7 to 3 by 6 weeks postoperatively, and she was delighted with her outcome.

Takeaways

Question: How can surgeons optimize outcomes for transhumeral TMR?

Findings: We report targeted radial nerve fascicular transfer utilizing internal-neurolysis of the radial nerve, distal to the branch of the long head of the triceps, to isolate the motor fascicle to the medial head. As such, native innervation of the triceps through the long head branch is preserved for signal acquisition.

Meaning: This approach allows preservation of a native triceps signal in all cases of transhumeral TMR through a single anteromedial incision, allowing greater efficiency and less morbidity than a two-incision approach. The fascicular nerve transfer may also be applied to TMR elsewhere.

DISCUSSION

The popularity of TMR continues to grow and has become the standard of care for amputee patients in many centers around the country. The advantages of the single incision approach for transhumeral TMR have previously been described.[5] However, access to radial nerve branches distal to the branch to the long head of the triceps is inconsistent and can be difficult from the anterior approach.

The cross-section fascicular anatomy of the radial nerve at the level of the axilla and proximal upper arm is very constant.[9] The branch to the medial head of the triceps consistently comes off the posterior aspect of the radial nerve and runs for most of its course in the mid and distal arm as a distinct branch. At the level of the axilla, it is easily neurolysed off the posterior aspect of the radial nerve proper, providing good length for an easy nerve coaptation. The fascicle to the lateral head of the triceps can also be neurolysed but is more difficult to access as it lies on the

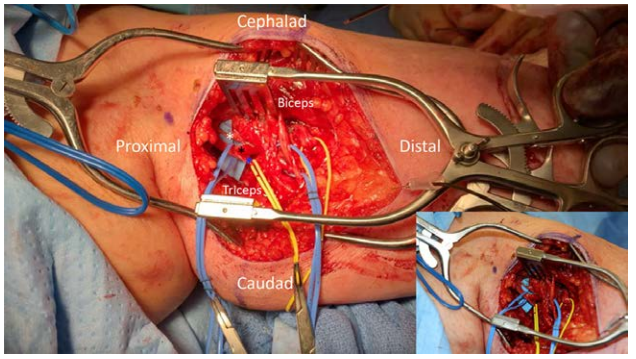

Fig. 1. Exposure of the radial nerve and its branches through an anteromedial arm incision. The white asterisk denotes the nerve to the long head of the triceps. The blue asterisk denotes the neurolysed fascicle to the medial head of the triceps, from the radial nerve. The black asterisk denotes the main trunk of the radial nerve. Figure inset shows unlabeled image.

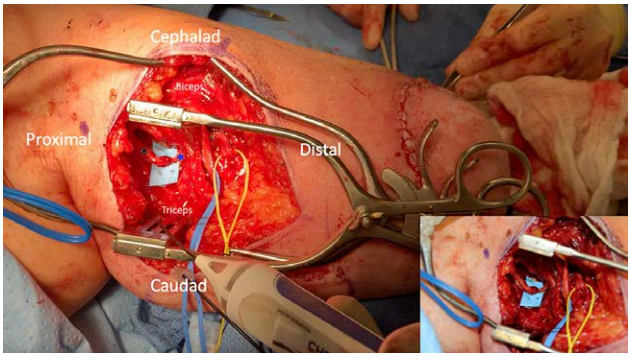

Fig. 2. After radial nerve TMR, coapting the main radial nerve to the fascicle to the medial head of the triceps. The black asterisk denotes the nerve proximal to the coaptation. The blue asterisk denotes the nerve distal to the coaptation. Figure inset shows unlabeled image.

deep surface of the radial nerve when approached from an anteromedial arm incision. Preservation of the branch to the long head preserves native triceps innervation when use of a myoelectric prosthesis is anticipated, or alternatively provides an additional target motor branch with a short transhumeral amputation, for the ulnar nerve, when the branch to the brachialis is not available.

Importantly, our concept of internal neurolysis and targeted fascicular transfer for TMR can also be applied to other major peripheral nerves where an obvious motor branch is not available as a target. Targeted stimulation of the main nerve with a nerve stimulator on 0.5 mA can identify a suitable motor fascicle if this has been preserved, in other situations.

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HELSINKI DECLARATION

All methodologies reported in this investigation conform to standards set in the Declaration of Helsinki.

PATIENT CONSENT

The patient depicted in this article gave consent prior to surgery and also prior to publication of this work.

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