Nerve Transfers

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KEYWORDS

• Nerve transfers • Peripheral nerve • Reconstruction • Sensory • Motor

KEY POINTS

- There is a time and place for each option on the reconstructive ladder, and, when appropriately selected, nerve transfers have been shown to restore function in cases previously deemed difficult or impossible.
- If the goal is to achieve motor function, the donor nerve should be as purely motor as possible. The same is true for sensory function.
- The functional loss from transferring the donor nerve should be less than the expected functional gain of the recipient nerve.

INTRODUCTION

Several options currently exist for the treatment of peripheral nerve injuries. Similar to planning a strategy for soft tissue coverage, repair of nerve injuries may be thought of as a reconstructive ladder. At the bottom of the ladder, nonoperative treatment is selected for self-resolving nerve insults such as neurapraxia. If the nerve is transected and a tension-free anastomosis is possible, primary repair is chosen. If the repair cannot be performed without tension, then the treatment options diverge depending on the patient and the type of injury.

The concept of nerve transfers is not new, but the technique is evolving and has gained acceptance over the years. There is a time and place for each option on the reconstructive ladder and, when appropriately selected, nerve transfers have been reliably shown to restore function in cases previously deemed difficult or impossible. This article discusses a brief history of nerve transfers, general principles, and some specific transfers, and provides an overview of postoperative rehabilitation following motor and sensory transfers.

HISTORY

Nerve transfers have been performed since the 1900s to treat root avulsion and other difficult nerve injuries. As early as 1921, Harris[1] described a radial to median nerve transfer to treat a low median nerve injury suffered during World War I; the patient's sensation gradually improved over the next 3 months. Pollock and Davis[2] were skeptical of the procedure, stating that "a complete return of physiologic function does not occur" after transfer. Despite this dismissal of the technique, Turnbull[3] reported on 4 radial to median nerve transfers in 1948. In his initial report, Turnbull[3] described return of sensation "of a 'crude' quality" in each of his 4 patients. He then examined these patients 16 years later and confirmed appropriate localization in 3 of the original 4 patients, although he again described their sensory results as "crude."[4] He concluded that these were better results than were previously thought possible, especially in otherwise irreparable nerve injuries.[3,4]

Despite these relative successes, nerve transfers still did not gain wide acceptance until the introduction of the microscope for nerve repairs in the 1960s.[5] In 1974, Sunderland[6] cited unpredictable and largely unsuccessful results with the radial to median nerve transfer, stating that using the superficial radial nerve for the procedure would remove too much sensation from the thumb, index, and middle fingers; he therefore proposed transfer of dorsal rami of the ulnar nerve to the median nerve instead. To further investigate

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Hand Clin 28 (2012) 571–577
http://dx.doi.org/10.1016/j.hcl.2012.08.007

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these criticisms, Chacha and colleagues[7–9] performed both Turnbull's[3] and Sunderland's[6] nerve transfers in monkeys. Certain enzymes, such as cholinesterase, are absent in cases of neuropathy and increase with intact nerve function. Chacha and colleagues[7] used these principles to show increased enzymatic activity and therefore nerve regeneration in the thumb, index, and middle fingers after both procedures.

In 1983, Bedeschi and colleagues[10] duplicated Turnbull's[3] and Sunderland's[6] transfers in human patients. Out of their 5 patients, 3 had excellent recovery at their 5-year follow-up. This result led them to confirm that nerve transfers were a reasonable surgical solution for long-standing median nerve injuries. Matloubi[11] built on these results by performing the transfers in 37 patients, and showed satisfactory to excellent results in all but 3 of his patients.

Around the same time as Turnbull's[3] work in the late 1940s, Alexander Lurje[12] treated a patient with Erb palsy by combining several transfers, including transferring the long thoracic nerve to the suprascapular nerve, the anterior thoracic to the musculocutaneous nerve, and the radial to the axillary nerve. In 1948, he showed good follow-up results in his patient; pectoralis and triceps function had improved, and the patient's atrophy of her deltoid, biceps, and scapular muscles disappeared.[12] However, for several decades afterward, further experimentation with transfers was delayed because of the great successes of Millesi and colleagues[13,14] with nerve grafts.[15] It was not until the 1970s and 1980s that interest in nerve transfers was revived. Even with Millesi and colleagues[13,14] advancement of nerve grafting techniques, loss of biceps function caused by brachial plexus injuries was too difficult to treat with nerve grafts alone.

One of the early revivals of transfers for biceps restoration was performed in the 1980s by Brandt and Mackinnon,[16] in which the medial pectoral nerve was transferred to the musculocutaneous nerve, and the lateral antebrachial cutaneous directly to the biceps muscle. Another transfer from the early 1990s for biceps flexion was the eponymous Oberlin transfer, in which a portion of the ulnar nerve was sutured to the motor nerve of the biceps.[17] Although modifications to this transfer have been described since, the procedure is still successful and has reproducible results.

Because of the increasingly reliable success with various nerve transfers, the concept and procedures have gained greater acceptance as a viable treatment strategy. Standard nerve transfers have been used more frequently, and innovative nerve transfers have been developed to treat a variety of deficits. The development and refinement of these procedures continues.

INDICATIONS

The benefits of nerve transfers are well described.[18] In most cases, as in the Oberlin transfer, there is only 1 neurorrhaphy site; with nerve grafts, there are 2. In addition, nerve transfers minimize the distance over which a nerve has to regenerate. Given that nerves regenerate approximately 1 mm/d, the distance involved in proximal nerve injuries is too great to expect significant recovery. A nerve transfer converts a high proximal nerve injury to a more distal nerve injury, which may accelerate muscle reinnervation.[19] For an elderly patient or patient with significant scarring, a nerve transfer is a good choice compared with a nerve graft requiring more extensive dissection.[20–22] In addition, with modern nerve stimulator technology, it is easier to ensure that a motor nerve is anastomosed to a motor nerve, and a sensory nerve to a sensory nerve. As Brenner and colleagues[23] have shown, this yields better results than if a mixed motor-sensory nerve is anastomosed to a pure motor nerve.

Although tendon transfers are common procedures in the setting of prolonged nerve deficits, nerve transfers require less dissection and postoperative immobilization.[24] Guelinckx and colleagues'[25] work on rabbits confirms that, functionally, simple tenotomy is inferior to reinnervating a denervated muscle. However, nerve transfers cannot replace tendon transfers or nerve grafts on the reconstructive ladder. For certain problems, the best surgical strategy for a patient might be a combination of both nerve and tendon transfers; for example, a median to radial nerve transfer combined with a pronator teres to extensor carpi radialis brevis tendon transfer.[21]

GENERAL PRINCIPLES

Considerations in selecting a donor nerve for nerve transfer include[24,26]:

- If the goal is to achieve motor function, the donor nerve should be as purely motor as possible. The same is true for sensory function.
- The functional loss from transferring the donor nerve should be much less than the expected functional gain of the recipient nerve.
- The donor nerve should be sufficiently mobilized to achieve direct anastomosis with the recipient nerve.
- The donor and recipient nerves should have similar caliber.
- Postoperative reeducation is crucial for functional recovery.