Upper Extremity Peripheral Nerve Injury

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Preface: *Fundamental principles of nerve repair have not changed since the advent of specialized instrumentation, magnification, and microsurgical technique. Adequate mobilization of proximal and distal aspects of a severed nerve is essential to optimize tension-free repair, and, absent that, nerve grafting has been the recommended alternative historically. In the upper extremity, dual imperatives exist: muscle recovery and restoration of sensation. My contribution to the 5 Points Series will address 2 relatively new alternatives to nerve grafting to achieve these outcomes. The first is the use of "nerve conduits" and the second is nerve transfer or "neurotization."*

Use of Nerve Conduits. The use of small-caliber nerve conduits is a simple and effective alternative to primary repair or nerve grafting for acute digital nerve lacerations. This technique obviates the need for an operative microscope. Placing an 8-0 horizontal mattress suture at each nerve end allows entubulation into the conduit and ensures adequate neural regeneration. Commercially available conduits are bioabsorbable and have optimal structure and material to support a fibrin clot and facilitate Schwann cell migration and extension of the growth cone. Although most commercially available conduits, including my preference—NeuraGen™ Nerve Guide (Integra, Plainsboro, NJ)—are limited to 2 cm in length, some studies suggest that nerve regeneration up to 3 cm occurs within conduits.[2]

Managing Neuromas. Neuromas in the upper extremity are painful and impair function. After either complete transection or partial injury, "stray" axons from the proximal stump (in the case of transection) or lateral outgrowth (in the case of partial injury) innervate the skin. It is useful to remember that a nerve placed into/beneath an "innervated" muscle will no longer sprout "stray" axons. In that light, digital neuromas should be resected and either reconstructed with conduits or mobilized proximally and transferred into a lumbrical muscle. The same principle can be applied to managing radial and ulnar sensory nerve neuromas. In addition, a nerve can be inserted into a conduit and the unattached end placed beneath muscle.

Alternatives to Primary Nerve Repair. When one is dealing with a mixed major peripheral nerve like the ulnar or median nerve at the wrist, primary nerve repair may not be possible, either because of a gap following débridement or because of delay and the secondary retraction and stiffness that are associated therewith. Nerve grafting with sural nerve has been the mainstay of treatment in such situations, but the development of commercially available conduits of sufficient diameter has allowed the use of so-called "entubulation" techniques, which harness the power of biology. That is, for a mixed nerve, neurotrophism allows "motor" fascicles to find "motor" and "sensory" to find "sensory." Arguably, the use of conduits may be more advantageous for a mixed nerve than a primary repair if absolutely perfect rotational alignment is not achieved.

Reinnervation of Intrinsics. When the ulnar nerve is lacerated high in the forearm or more proximally, reinnervation of the intrinsic muscles is often unlikely, even if repair or grafting is performed, because of the distance between the proximal stump and the end organ. A useful alternative relies on nerve transfer between the anterior interosseous nerve and the motor branch of the ulnar nerve. The former is mobilized from within the pronator quadratus muscle. The latter is traced back from its separation from the ulnar nerve at the level of the piso-hamate ligament, and an end-to-end repair is possible. In other words, an "eyeball" neurolysis of motor fascicles is performed from the motor branch proximally. This then allows tension-free repair well proximal to Guyon's canal, without having to surgically separate motor from sensory fascicles the entire distance.

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Reinnervation of intrinsics is facilitated because of the proximity of the "new" motor fibers, in contrast to the distance from the elbow to the hand if reconstruction at the elbow was the path that reinnervating axons were to take. In such cases, proximal reconstruction is still advised in order to restore ulnar nerve distribution sensation.

New Strategies for Restoring Biceps or Shoulder Function. When an upper trunk brachial plexus injury occurs, and biceps muscle function does not return, supraclavicular exposure with neurolysis and grafting has been the historical mainstay of treatment to restore elbow flexion. Contemporary treatment protocols rely more commonly on "neurotization." One such strategy to restore motor function to the biceps leverages the feasibility of nerve transfer with the advantage of "proximity" of the adjacent motor fibers. Thus, the "Oberlin" transfer involves a transfer from the ulnar nerve, which innervates the flexor carpi ulnaris (based on intraoperative nerve stimulation) to the motor nerve branch from the musculocutaneous nerve, which innervates the biceps muscle. If shoulder function is absent as well, nerve transfer alternatives to shoulder arthrodesis are also possible. These typically include spinal accessory transfer to suprascapular nerve and phrenic transfer to the axillary.

Authors' Disclosure Statement

The author reports no actual or potential conflict of interest in relation to this article.

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LETTERS TO THE EDITOR

Managing Torus Fracture of the Radius

In the December 2004 issue, the article, Imaging Consultation: Torus Fracture of the Radius (*Am J Orthop.* 2004 December; 33[12]:625), contains 2 statements near the end of the paper that are in error. These read "Torus fractures are managed by applying a tightly fitting cast for two to four weeks. This aims to relieve pain and to prevent the development of angular deformity." This is incorrect on 2 counts. Torus fractures only **rarely** develop angular deformities, and **no cast should ever be applied tightly.**

Alan J. Zimmerman, MD
Lido Beach, New York

In Reply:

Dr. Zimmerman is correct. When immobilization is indicated for immature forearm fractures, a **well-molded** cast is applied. Torus fractures, which are typically found in the distal metaphysis of the radius, are immobilized primarily for comfort. Small amounts of angulation in the plane of the joint motion are corrected by remodeling. Angulation is, however, rare.

John S. Gould, MD
Editor in Chief

In Reply:

To add to this commentary, we would note that "greenstick" midshaft both-bone fractures in children may deform with malrotation and apparent angulation, requiring appropriate reduction and a well-molded long arm cast. Finally, distal radial epiphyseal injuries require careful reduction and appropriate casting, but they may have deformities related to growth arrests despite good initial care.

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and Wilfred C. G. Peh, MD, FRCP, FRCR
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