Nerve Repair and Nerve Grafting

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KEYWORDS

• Nerve injury • Nerve repair • Nerve autograft • Nerve grafting • Nerve repair outcomes

KEY POINTS

- Depending on the mechanism of injury, time since injury, and defect length, direct repair or nerve autografting are primary options for upper extremity peripheral nerve injuries.
- Principles of direct repair and nerve autografting, including donor selection, are reviewed.
- The outcomes, and factors associated with outcomes, of upper extremity peripheral nerve repair and autografting are reviewed.

DIRECT REPAIR

Introduction

The mechanism of injury (eg, closed crush injury vs sharp laceration), location of injury, zone of injury, time since injury, and degree of neurologic impairment are important decision-making factors in the treatment of upper extremity peripheral nerve injuries. An epidemiologic study in the United Kingdom reported that upper extremity peripheral nerve injuries more commonly occurred in males (3:1), in the distal extremity, and secondary to sharp laceration in a domestic or industrial setting.[1] The most commonly injured upper extremity peripheral nerves were the index radial digital nerve and small finger ulnar digital nerve.[1]

Timing

Direct end-to-end repair of a lacerated nerve is ideally performed in the acute setting (ie, within 3 days). The advantages of acute repair include the ability to perform intraoperative nerve stimulation, to optimize motor nerve recovery, and to adequately gain exposure and mobilize nerve ends without scar tissue hindrance.[2] From a biomechanical standpoint, nerve ends have been reported to still contain neurotransmitters within 72 hours of injury.[2] From a histopathologic standpoint, nerve ends have symmetrically apposed fascicles immediately after transection but then become increasingly difficult to match, as Schwann cell proliferation, fibrosis, and angiogenesis occur at each end.[3]

The primary disadvantage of early nerve repair is the inability to accurately assess the zone and extent of injury (eg, in the setting of crush injuries). Direct nerve repair after longer time intervals has been described as delayed primary suture (up to 3 weeks) and secondary suture (greater than 3 weeks; requiring resection of neuroma proximally and glioma distally).[4] However, numerous studies have reported that a well-performed primary nerve repair has a significantly better outcome than either delayed end-to-end repair or delayed nerve grafting.[5–7] The importance of early repair has been reported in multiple upper extremity peripheral nerves, including the median, radial, ulnar, and musculocutaneous nerves.[5,8–10]

Disclosure Statement: No disclosures (S.K. Trehan and Z. Model); Arthrex (royalties; consulting), BioMedical Enterprises (consulting), AxoGen (consulting; research support), Checkpoint (consulting; research support), Integra (research support) (S.K. Lee).

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Hand Clin 32 (2016) 119–125

http://dx.doi.org/10.1016/j.hcl.2015.12.002

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Technique

Several technical principles of direct nerve repair must be highlighted. First, adequate visualization of relevant neural, vascular, and musculoskeletal structures is required for precise end-to-end nerve repair. Although large nerves can be repaired under high-powered loupe magnification (ie, at least 3.5×), smaller branches usually benefit from use of the microscope (12× to 15× magnification).[11] Adequate exposure also entails injured nerve end resection in order to visualize healthy nerve tissue and facilitate fascicle apposition. Given the healing process initiated at the nerve ends after traumatic injury, more end resection is required as the time from injury increases. How much nerve to resect because of neuroma and/or damage is controversial and ultimately based on the surgeon's experience and preference. Common methods used are external and internal visualization (eg, fascicular structure and bleeding), palpation, pliability, intraoperative histology, and intraoperative nerve studies (eg, nerve action potentials and somatosensory evoked potentials). At the authors' institution, they use all of the aforementioned methods; but in cases whereby there is uncertainty, they used intraoperative histology. The authors' threshold for adequate nerve health is at least 75% preservation of fascicular architecture.[12,13]

Secondly, the nerve ends must be neurolysed from the surrounding scar tissue bed. During this step, it is critical to avoid physical damage (ie, crushing or tearing) to the nerve ends.[3] In addition, nerve repairs should be performed in a well-vascularized tissue bed.[14] Third, repair must be achieved with minimal tension.[15] Minimal tension is emphasized because even in the setting of a fresh nerve laceration, some tension exists because of the elastic nature of nerves. Nerve repairs under tension have been shown to result in nerve ischemia and repair mechanical failure in a rat model.[16] Assessing repair tension intraoperatively is an important component of repair, and multiple technical recommendations have been described. Unfortunately these technical recommendations have yet to be comparatively tested in a rigorous scientific fashion. de Medinaceli and colleagues[17] reported that failure to hold an end-to-end repair with a single 9-0 suture was a sign of undue tension. For nerves of the wrist and forearm, one can place a single 7-0 nylon epineural suture with wrist flexed less than 30° and determine whether the suture holds the ends together without epineural tearing and/or blanching of the epineural vessels.[4] The importance of minimizing tension on the nerve repair must be considered postoperatively as well because certain repairs will require splint immobilization to prevent joint range of motion. In addition, Bertelli and colleagues[18] and Kechele and colleagues[19] have advocated the use of polypropylene mesh to augment direct epineural repairs ("epineural splinting") in order to minimize tension at the repair site.[18,19]

Finally, nerve repair can be performed by suture placement in either the epineurium or the perineurium. The theoretic advantage of perineural sutures is that these repairs repair individual fascicles, thus allowing identification of sensory versus motor fascicles and allowing appropriate alignment and potential improvement in outcomes.[20] The theoretic disadvantage is that placement of these sutures requires greater dissection and trauma to the nerve, increased operative time, increased suture material, and is technically demanding.[11] Epineural repair, on the other hand, aligns the nerve ends only. Several investigators have demonstrated no difference between fascicular and epineural repairs for peripheral nerve injuries.[21–23]

Author's Preferred Method

The senior author's preferred indication for direct nerve repair is an acute nerve laceration with minimal gap, easily mobilized nerve ends after resection, and minimal repair tension without restricted adjacent joint range of motion. An operative microscope is usually used for all nerve repair cases as it aids in accurate placement of epineural sutures and minimizes damage to nerve tissue. A few epineural sutures are placed (Fig. 1), the preferred suture material being nylon with caliber typically 8-0 or 9-0. The repair is performed on a blue

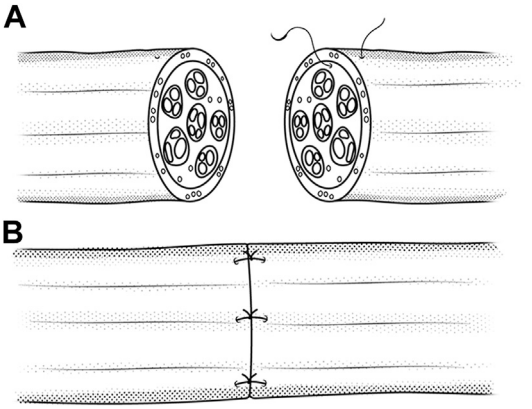

Fig. 1. Direct repair with epineural sutures. (*A*) Suture passed through epineural tissue only (ie, not fascicles). (*B*) Direct repair with epineural sutures resulting in nerve end approximation.

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