

Options for Digital Nerve Gap

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THE PATIENT

A 27-year-old bicyclist fell during a race, crushing the ring and little fingers of the dominant hand between the handlebar and the ground. The associated skin laceration was primarily repaired over a 1×1 -cm area of soft tissue crush injury at the base of the little finger. She has no fractures and good perfusion to the fingers but has lost sensation on the ulnar aspect of the little finger. She is taken to surgery within 3 days for nerve repair; intraoperatively, there is a 9-mm gap between nerve ends. Trimming the nerve back to normal fascicles leaves a 12-mm nerve gap.

THE QUESTION

Based on the existing clinical evidence, which technique of nerve reconstruction will offer good sensory recovery for a patient with a digital nerve gap?

CURRENT OPINION

When tension-free end-to-end nerve repair is unachievable, as in this patient, several options are available, including nerve autograft, nerve allograft, and various autologous or synthetic nerve conduits. Over the past decade, surgeons have used all of these options with moderate to good recovery of 2-point discrimination (2PD). Use of off-the-shelf collagen conduits and other conduits is becoming more popular because they avoid potential donor site morbidity and result in shorter operative times.

THE EVIDENCE

Comparative studies

A prospective randomized trial comparing polyglycolic acid (PGA) synthetic conduits, direct repair,

and nerve autograft in 136 nerve repairs demonstrated equivalent or better sensory outcomes with PGA conduits. For gaps 4 mm or less, PGA conduits restored a moving 2PD of 3.7 ± 1.4 mm compared with 6.1 ± 3.3 mm for end-to-end repairs ($P = .03$). For gaps larger than 8 mm, PGA conduit reconstructions similarly had improved 2PD (6.8 ± 3.8 mm) relative to direct repairs (12.9 ± 2.4 mm; $P < .01$). It was also noted that avulsion or crush mechanisms resulted in poorer 2PD: 9.3 ± 5.1 mm compared with 6.7 ± 3.8 mm for non-crush/avulsion mechanisms ($P = .04$).¹

A recent prospective randomized trial compared 32 autogenous vein conduits (ipsilateral dorsal forearm or hand) with 36 PGA synthetic conduits² for patients with a mean 10-mm nerve defect. The moving 2PD for the PGA conduit group was 5.6 ± 2.2 mm compared with 6.6 ± 2.9 mm for the vein conduit group 12 months after surgery (not statistically significant). The costs were similar owing to longer operative time for the vein harvest. Smokers and workers' compensation patients had significantly worse sensory recovery 12 months after repair, but the authors did not explain how insurance status could affect 2PD.²

Bertleff et al³ reported a randomized trial evaluating sensory recovery in nerve deficits less than 20 mm by comparing Neurolac (poly[DL-lactide-ε-caprolactone], Polyganics BV, Groningen, The Netherlands) reconstruction against standard repair techniques (direct end-to-end repair or nerve autograft). This was a multicenter study that included 34 nerve reconstructions. The researchers found that the Neurolac was well accepted in most patients; however, some experienced wound problems such as delayed wound healing, inflammation, and foreign body responses. There were no statistically significant differences in sensory outcomes (static and moving 2PD) between the Neurolac and standard repair groups; however, these numerical results and P values were not quantified in the article.³

Nerve autografts

Stang et al⁴ reported similar sensory outcomes when comparing patients treated with posterior interosseous nerve (PIN) grafts with medial antebrachial cutaneous nerve (MABCN) grafts. Fourteen of the 16 patients with PIN grafts achieved S3+ or S4 sensibility, as did 9 of the 12 patients with MABCN grafts. The PIN

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Received for publication August 30, 2014; accepted in revised form September 25, 2014.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/15/4001-0026\$36.00/0
<http://dx.doi.org/10.1016/j.jhssa.2014.09.022>

graft harvest, however, offered less donor site scar formation, unpleasant paresthesia, and neuroma-associated pain than MABCN harvest.

Chen et al⁵ described a procedure for reconstruction of proper digital nerve gaps in the thumb using a neurovascular graft based on the second dorsal metacarpal artery. The pedicled nerve, which is a dorsal branch of the proper digital nerve of the index finger, is transferred with its vascular supply to the thumb. In their comparison with nonvascularized nerve autograft from sural nerve or MABCN, the authors noted significantly better sensory recovery with the neurovascular graft in 2-point discrimination ($P = .000$) and Semmes-Weinstein monofilament testing ($P = .001$). They also reported results of a similar transfer of the dorsal branch of the proper digital nerve without vascularized pedicle. This nerve transfer also demonstrated superior sensory function relative to sural autograft.⁶

Pilanci et al⁷ also reported on the ability to harvest up to 3.0 cm of lateral antebrachial cutaneous nerve in the forearm. They evaluated 15 patients, most of whom had flexor zone 2 digital nerve injuries, and examined sensory recovery and 2PD after lateral antebrachial cutaneous nerve digital nerve reconstruction. Nine patients had S4 sensation, 6 had S3+, and 13 had good to excellent 2PD results. They noted minimal donor site morbidity; only 2 patients reported minimal cold intolerance at the donor site.

Nerve allograft

The largest retrospective evaluation was a multicenter study that assessed 76 peripheral nerve allograft reconstructions, of which 48 were digital nerve injuries. They found an overall functional recovery rate of 87% with successful reinnervation of 89% of sensory nerves.⁸ Taras et al⁹ prospectively evaluated 18 nerve allograft reconstructions for mean nerve gaps of 11 mm and found that 15 had good or excellent results. Static and moving 2PD improved to 5.0 and 5.2 mm, respectively, and patients had good visual analog scale pain scores, with no evidence of infection or graft reaction.

Another study found that allografts might be effective for nerve gaps up to 50 mm in the upper extremity, demonstrating meaningful sensory recovery (S3 or greater) in 31 of 35 digital nerve reconstructions (89%; mean gap, 23 mm; range, 5–50 mm).¹⁰

Autologous vascular graft conduits

Venous and arterial grafts have also been used for nerve reconstruction, although veins have historically had more success than arteries.¹¹ In addition to the study described above, studies with lower levels of evidence have also used venous grafts for nerve gaps up to 30 mm

(static 2PD 11.1 ± 3.4 mm; moving 2PD 6.5 ± 2.6 mm),¹² chronically neglected digital nerve injuries (static 2PD 4–6 mm; moving 2PD 3–5 mm),¹³ and traumatic nerve injuries treated within 24 hours (static 2PD 8–13 mm).¹⁴ However, vein grafts may be effective only for short nerve defects because of their collapsibility.^{11,15}

Muscle-in-vein grafts

Battiston et al¹⁶ described a novel clinical use of vein grafts surrounding skeletal muscle fibers that acted as a scaffold for nerve repair in 2000. A retrospective series of 22 digital nerve reconstructions in 17 patients by Ignazio and Adolfo¹⁷ for gaps up to 35 mm demonstrated improvements in static and dynamic 2PD, Semmes-Weinstein monofilament testing, and Disabilities of the Arm, Shoulder, and Hand scores in most patients. Of the 22 reconstructed nerves, 17 had S3 or S4 results and 5 had S2 or S1 results.¹⁷ Tos et al¹⁸ also supported the use of muscle-in-vein nerve grafts in a retrospective study of 16 patients who had crush injuries to digital nerves and other mixed nerves. Fifteen of 16 patients had some functional recovery, including all 8 with digital nerve injuries. This method of muscle-in-vein nerve repair may be advantageous for small to moderate nerve gaps up to 60 mm, while avoiding sacrifice of a donor nerve. The tissues are abundantly available and easily fashioned into a graft, and the conduits are immunologically compatible.^{15,17,18}

Collagen conduits

Bushnell et al¹⁹ reported good or excellent sensory outcomes in 8 of 9 patients (89%) treated with collagen nerve conduits, whereas Wangenstein and Kallianen²⁰ retrospectively reviewed 82 digital nerve reconstructions and noted improvements in only approximately 40% of repairs, with a higher revision rate. Lohmeyer et al²¹ prospectively evaluated 12 patients and found 9 of 12 (75%) to have good or excellent results for mean nerve gaps of 12.5 mm, and Taras et al²² reported similar good to excellent sensory outcomes in 16 of 22 of patients (73%). However, Lohmeyer et al²³ more recently reported that only 20 of 40 patients (50%) had excellent or good sensory outcomes in a larger 2-center prospective cohort, with 9 of 40 nerve reconstructions achieving no sensation recovery. Another series found a 59% sensory recovery rate in 45 nerve repairs at 12 months postoperatively,²⁴ and collagen conduits were also found to be useful for posttraumatic neuromas of digital nerves.²⁵

Synthetic polyglycolic acid conduits

Mackinnon and Dellon²⁶ reported on 15 patients with nerve gaps up to 30 mm, who had PGA conduit nerve

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