The Management of Digital Nerve Injuries

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A tension-free coaptation is a key factor for the successful outcome of any nerve repair. A variety of host factors influence the outcome of digital nerve repair more than the type of repair per se. Although autologous graft remains the reference standard for reconstruction of any critical digital nerve defect, allografts and conduits have assumed an increasing role. *(J Hand Surg Am. 2014;39(6):1208−1215. Copyright © 2014 by the American Society for Surgery of the Hand. All rights reserved.)*

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Nerves to the digits are composed of 3 terminal branches from either the radial, median, or ulnar nerve. Distal to the transverse carpal ligament, the median nerve splits into lateral and medial branches. The lateral branch supplies a motor branch to the thenar muscles and then divides into 3 proper palmar digital nerves. The common digital nerve to the thumb splits into a radial and ulnar digital branch. The second common digital nerve supplies a motor branch to the index lumbrical and supplies sensation to the radial side of the index. In the distal palm, the medial branch of the median nerve divides into 2 common palmar digital nerves. The first innervates the second lumbrical and runs toward the index and middle fingers, where it divides into 2 proper digital nerves. The second common palmar digital nerve runs toward the middle and ring fingers and splits into 2 proper digital nerves. Each proper digital nerve in the finger gives off a dorsal branch at or proximal to the A1 pulley in the fingers that joins the dorsal digital nerve, a terminal segment of the superficial branch of the radial nerve. The dorsal branch from the proper digital nerve perforates the connective tissue septum (Cleland's ligament) and anastomoses with the dorsal digital nerve. This nerve innervates the skin on the dorsal aspect of the last phalanx. At the terminal aspect of each digit, the proper digital nerve divides again into 2 branches; 1 supplies the pulp and the other splits around and underneath the nail. As they run along the lateral aspect of each finger, the proper digital nerves are superficial to the corresponding arteries. There are no connections between the dorsal sensory nerve and the dorsal branch of the proper digital nerve in the thumb.

There is great variation in the course that the proper digital nerve takes to the tip of the finger. Commonly, it passes between the superficial and deep transverse metacarpal ligaments. As it moves distally, it lies palmar to the adjacent artery at the side of the fibrous flexor sheath. At the distal digital crease, it goes on to divide into multiple branches that terminate at the pulp and nailbed. There is no cross-over innervation of the pulp. Anatomical studies have shown that there is little change in diameter of the nerve as it makes its way distally.

The ulnar nerve bifurcates approximately 5 cm proximal to the wrist into the dorsal branch and volar branch. The dorsal branch of the ulnar nerve passes beneath the flexor carpi ulnaris, perforates the deep fascia, and runs along the ulnar side of the back of the hand. As it proceeds through the midhand, it divides into 2 dorsal digital branches. One branch supplies sensation to the dorso-ulnar side of the little finger, and the other to the adjacent side of the little and ring fingers. It also sends a small branch to join with the superficial branch of the radial nerve for the adjoining sides of the middle and ring fingers. The dorsal digital branch extends to the base of the distal phalanx in the little fingers and to the base of the second phalanx in

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the ring fingers. The distal aspects are supplied by the dorsal branches from the proper volar digital branch of the ulnar nerve. The volar branch of the ulnar nerve crosses the transverse carpal ligament on the lateral side of the pisiformis and ends by dividing into a superficial and a deep branch. The superficial branch supplies the skin on the ulnar side of the hand by dividing into a proper volar digital branch for innervation of the ulnar side of the little finger. In addition, a common volar digital branch is given off that divides into 2 proper digital nerve innervating the adjoining side of the little and ring fingers volarly.

Nerve regeneration does not involve mitosis and multiplication of nerve cells. Instead, the cell body restores nerve continuity by growing a new axon. One axon sends out multiple unmyelinated axon sprouts from the tip of the remaining axon or collateral sprouts from a nearby proximal node of Ranvier. The distal sprout contains the growth cone. This sends out filopodia, which adhere to sticky glycoprotein molecules in the basal lamina of Schwann cells, such as laminin and fibronectin (neurite-promoting factors). The filopodia contain actin, which aids in pulling the growth cone distally. The basal lamina of 2 abutting Schwann cells form a potential endoneurial tube into which the regenerating axon grows. These axons will deteriorate if a connection with a target organ is not reached. Unlike the motor end plate, sensory end organs remain viable because there is no end plate and they retain the potential for reinnervation. Reconstruction of a sensory nerve defect, by comparison, may provide protective sensation even after many years.[1]

A normal nerve has longitudinal excursion, which subjects it to a certain amount of stress and strain *in situ*. For example, the median nerve moves as much as 12.4 mm with wrist motion at the carpal canal.[2] A peripheral nerve is initially easily extensible, but this rapidly diminishes with further elongation owing to stretching of the connective tissue within the nerve. The perineurium is a mechanically strong membrane and is a major load-carrying connective tissue component that can sustain intrafascicular pressure elevations of up to 750 mm before rupturing.[3] The epineurium is a loose connective tissue layer that allows a certain amount of nerve gliding. Chronically injured nerves become even stiffer. Elasticity decreases by as much as 50% in the delayed repair of nerves in which Wallerian degeneration has occurred. Experimentally, blood flow is reduced by 50% when the nerve is stretched 8% beyond its *in vivo* length. Complete ischemia occurs at 15% of nerve elongation. Suture pullout from the neurorrhaphy site does not occur until a 17% increase in length.[4] This suggests that ischemia, and not disruption of the neurorrhaphy, is the limiting factor in acute nerve repairs.[4] This observation is also applicable to nerve grafting.

There is a difference between a nerve gap and a nerve defect. A nerve gap refers to the distance between the nerve ends resulting from the elastic retraction that occurs immediately after nerve severance, whereas a nerve defect refers to the actual amount of nerve tissue that is lost. With simple nerve retraction after division, the fascicular arrangement is similar. As the nerve defect between the proximal and distal stumps increases, there is a greater fascicular mismatch between the stumps. This is of minimal consequence with digital nerve repairs because all of the fascicles contain only sensory fibers, but fascicular mismatch can still lead to an alteration of the sensory distribution to the fingertips in common digital nerve repairs.

CLINICAL PICTURE

The patient typically presents with a history of a laceration to the palm or digit by glass or a knife, although puncture wounds caused by a drill bit can cause more extensive damage. A common digital nerve injury to the thumb will result in a sensory defect along the radial and ulnar aspects of the distal thumb. The patient with a common digital nerve injury in the palm will present with a sensory deficit along the adjacent sides of the second or third webspace (median nerve) or the fourth webspace (ulnar nerve). A proper digital nerve injury will result in an isolated sensory deficit along the radial or ulnar aspect of the thumb or digit. Static 2-point discrimination (S2PD) and moving 2PD (M2PD) testing will be greater than 25 mm on the affected side(s, which is equivalent to a complete sensory loss. Normal S2PD is 6 mm or less, whereas 15 mm is equivalent to a loss of protective sensation. Semmes Weinstein monofilament (SWM) testing will be greater than 6.65. This can easily be tested in the emergency room or office setting using the West Enhanced Sensory Test, which consists of a handle with 5 monofilaments. Measuring individual digital nerve action potentials can aid in the diagnosis of isolated digital nerve injuries (Fig. 1 A, B).[5] Errors owing to volume conduction from an intact digital nerve on the opposite side must be watched for. Occasionally, it is necessary to perform a digital nerve block of the unaffected side to prevent contamination of the response in the nerve under consideration. Lacerations proximal to the takeoff of the dorsal sensory branch in the digits will also result in a sensory deficit

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