

Ten Tips to Simplify the Spaghetti Wrist

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Summary: Hand surgeons refer to deep lacerations of the volar distal forearm as “spaghetti wrists.” Given that multiple tendons, vessels, and nerves often require repair, this injury may be intimidating. We review management of spaghetti wrists and summarize with 10 simplifying tips. (*Plast Reconstr Surg Glob Open* 2018;6:e1971; doi: 10.1097/GOX.0000000000001971; Published online 12 December 2018.)

INTRODUCTION

The idiom “spaghetti wrist” refers to a deep laceration of the distal volar forearm. Because structures at the wrist are tightly packed and thinly covered, lacerations of tendons, nerves, and arteries are likely. Exposed tendons on a red background resemble pasta noodles in a bed of tomato sauce. Despite the term being more colorful than scientific, it is accepted by hand surgeons. The expression “full house” is also occasionally used.¹ There is, to our knowledge no alternative, more formal descriptor.

A spaghetti wrist injury commonly occurs when a patient punches a glass window. The same injury may result from an accident with sheet metal, from an assault with a knife, or may be self-inflicted.

A short laceration of the skin may belie damage beneath. Unless intact antebrachial fascia is clearly visible throughout the depth of the wound, major injury should be assumed. When present, arterial bleeding makes deeper injury more obvious. Bleeding of this sort should be stopped with direct pressure over the laceration, and if still uncontrolled, with a temporary tourniquet. One should avoid clamping or tying vessels without clear visualization. The patient should be evaluated for hemorrhagic shock and resuscitation should begin accordingly.

Once the patient is hemodynamically stable, the vascular status of the hand may be assessed. Any tourniquet should be let down, and any compressive dressing should be loosened so that it does not impair otherwise intact flow to the hand. Capillary refill in the fingertips is assessed by pressing lightly on the paronychia folds or the fingernails. A Doppler ultrasound device may also be

used. Doppler probes in the emergency room are fragile and often broken. The probe should be tested on the examiner’s own radial artery before being used to examine the patient. The tip of the Doppler probe is placed on the center of the fingertip whorl (Fig. 1). Pulsatile signal in all of the fingertips implies a well-perfused hand. In the absence of this, the injury should be treated as an emergency and preparations made for surgery. If the patient’s hand is perfused, and bleeding is controlled, the repair might theoretically be delayed for several days. Cut tendons, nerves, and vessels retract and only become more difficult to repair with time. For these reasons, the authors recommend definitive operative repair within 24 hours of injury.

There is risk and no utility in exploring the wound in the emergency room. A sensory and motor examination, however, may provide useful additional information. Whether or not the patient can feel light touch on the tips of their digits is relevant. Flexor tendon lacerations cause involved digits to fall into extension, and the injured hand may lose its resting half-fist digit cascade (Fig. 2). The flexor digitorum superficialis (FDS) tendons to any single finger may be tested by holding the other fingers out to length. This eliminates the action of the single flexor digitorum profundus (FDP) muscle belly and makes any observed active flexion the result of an intact FDS tendon. Only the FDP crosses the distal interphalangeal joint and the presence of active flexion here implies an intact profundus tendon (Fig. 3). In a patient who cannot follow commands, gross assessment of flexor tendon continuity may be accomplished with direct pressure on the volar forearm proximal to the laceration. This shortens the tendons and will flex digits with intact myotendinous units (Fig. 4). The fingers may also be observed as the wrist is passively moved from flexion to extension. Changes in the normal tenodesis affect imply injury to the tendons.

As a note of caution, the described sensory and motor examinations are only reliable in a relaxed subject, and few patients with this injury may be described as such. Pain limits the utility of a motor examination as do anomalous or fascial connections between the tendons. Tendons with

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Received for publication July 16, 2018; accepted August 14, 2018.

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DOI: 10.1097/GOX.0000000000001971

Disclosure: The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors.

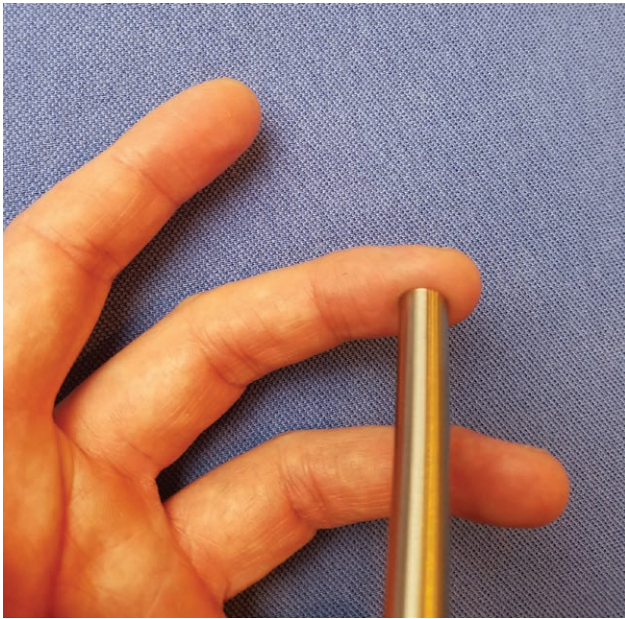


Fig. 1. The tip of the Doppler probe should be placed on the center of the fingertip whorl.

near-complete lacerations may seem intact. These injuries are almost always worse than they appear.

Radiographs should be performed to rule out fractures and potentially locate broken glass, the tip of a knife, or other foreign material.

INDICATIONS AND CONTRAINDICATIONS

Isolated injury to the palmaris longus might not warrant a formal surgery. Any other cut flexor tendon, major nerve, or major artery should be repaired urgently in the operating room.

A devascularized hand is an indication for emergency surgery unless the patient's life is otherwise in danger.

Segmental lacerations, other trauma to the limb, heavy contamination, and prolonged ischemia might make limb-salvage impossible. Amputation would be appropriate in these cases.

Patients with self-inflicted injuries or major psychiatric disorders might require delayed repair or emergency physician consent for surgery.

ANATOMY

The radial and ulnar arteries are framed by their respective nerves at the wrist, that is, the vessels are on the inside and the nerves are on the outside.² The median nerve is sandwiched between the FDS and FDP muscle-tendon units in the forearm. The palmar cutaneous branch originates from the median nerve roughly 5 cm proximal to the wrist. The dorsal sensory branch of the ulnar nerve also diverges roughly 5 cm proximal to the wrist flexion crease and crosses from volar to dorsal just proximal to the ulnar styloid.

The FDP tendons lie flat against the interosseous membrane proximally and the pronator quadratus distally. The FDP myotendinous junction is a tendinous sheet rather



Fig. 2. Flexor tendon lacerations cause involved digits to fall into extension, and the injured hand may lose its resting half-fist digit cascade.

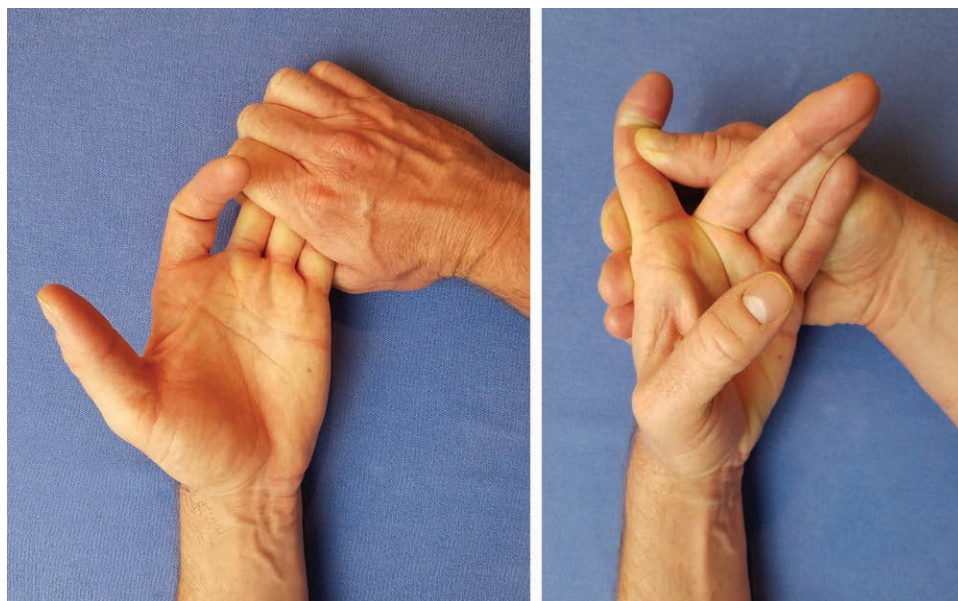


Fig. 3. The FDS tendons to any single finger may be tested by holding the other fingers out to length. This eliminates the action of the single FDP muscle belly and makes any observed active flexion the result of an intact FDS tendon. Only the FDP crosses the distal interphalangeal joint and the presence of active flexion here implies an intact profundus tendon. FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis.

than individual tendons, although the tendon to the index finger is usually independent (Fig. 5). The flat and parallel arrangement of FDP tendons is maintained distally in the carpal tunnel. The FDS tendons are separate



Fig. 4. Pressure on the volar forearm shortens the tendons and will flex digits with intact myotendinous units.

and coplanar in the forearm. They overlap one another in the carpal tunnel, however, so that the slips to the ring and long fingers are immediately superficial to the index and small finger tendons (Fig. 6). The flexor carpi ulnaris (FCU) tendon is parallel to the forearm axis and immediately superficial and ulnar to the ulnar neurovascular bundle. Whereas its counterparts are bare, the FCU tendon is the only volar tendon accompanied by muscle tissue at the wrist. The flexor carpi radialis (FCR) tendon lies obliquely over the FDS and FDP tendons. It is particularly superficial and encased in a fascial sheath confluent with the antebrachial fascia.

TECHNIQUE

Incision

Prepare or allow access to the ipsilateral anterolateral thigh for harvest of a split-thickness skin graft.

After inflation of an upper-arm tourniquet, the laceration should be extended so as to provide adequate

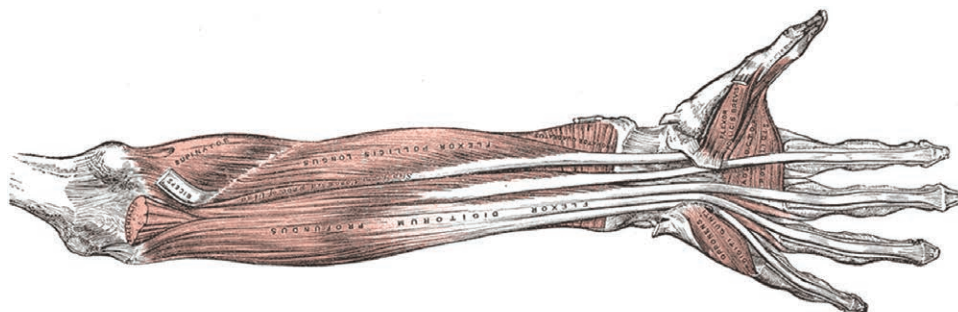


Fig. 5. The FDP myotendinous junction is a tendinous sheet rather than individual tendons, although the tendon to the index finger is usually independent.

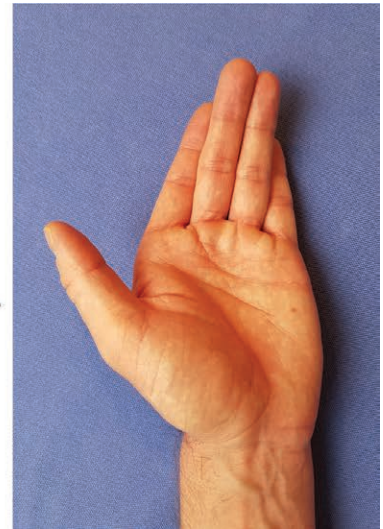
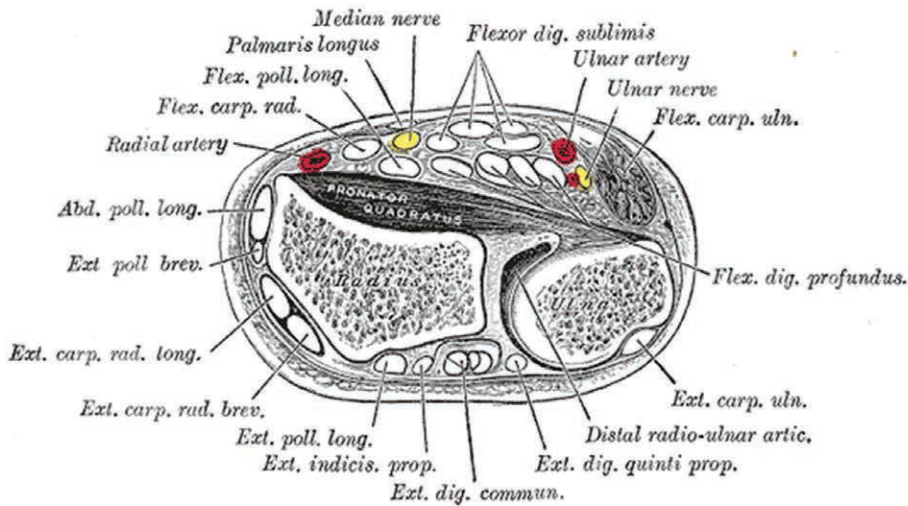


Fig. 6. The FDS tendons are separate and coplanar in the forearm. They overlap one another in the carpal tunnel, however, so that the slips to the ring and long fingers are immediately superficial to the index and small finger tendons. This relationship can be demonstrated by holding the fingers as shown.

exposure and to facilitate skin grafting over muscle should direct closure be impossible. A transverse incision should be extended radially and ulnarly to the borders of the forearm. This incision may be then made into a “T” or an “H” by adding an ulnar longitudinal limb or ulnar and radial limbs, respectively (Fig. 7).

Oblique lacerations should be incorporated into a longitudinal ulnar incision. Many surgeons are familiar with a forearm fasciotomy incision that creates a large, rounded, ulnarly based flap of forearm skin. We favor a more ulnar, longitudinal incision when possible (Fig. 8). An ulnar and longitudinal incision creates a less conspicuous scar and

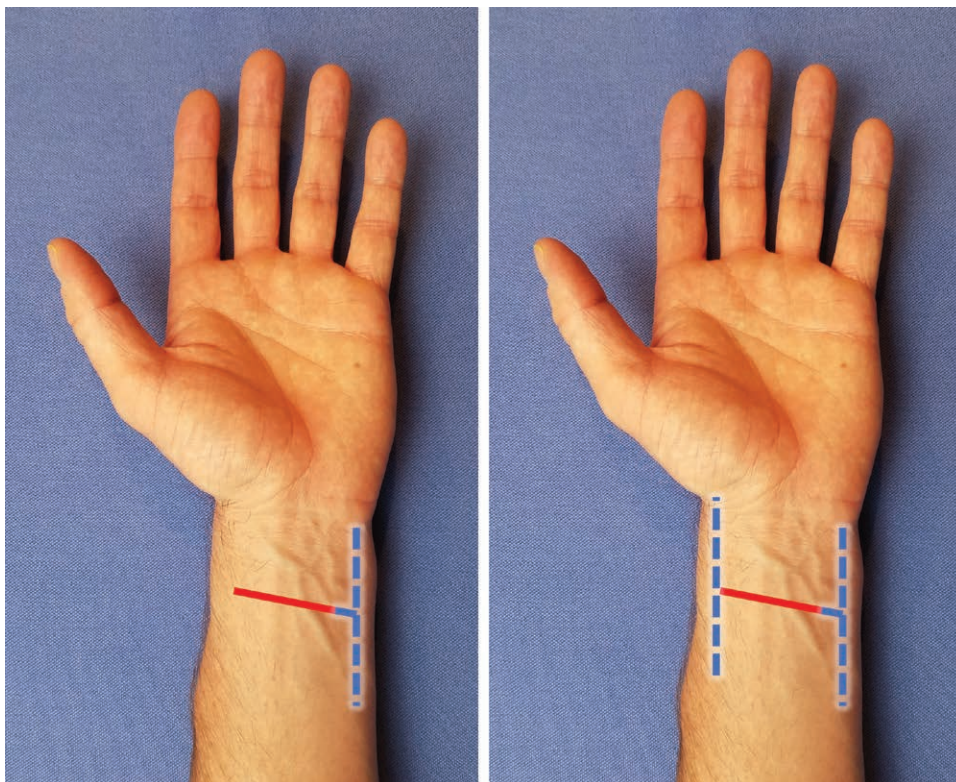


Fig. 7. A transverse incision should be extended radially and ulnarly to the borders of the forearm. This incision may be then made into a “T” or an “H” by adding an ulnar longitudinal limb or ulnar and radial limbs, respectively.

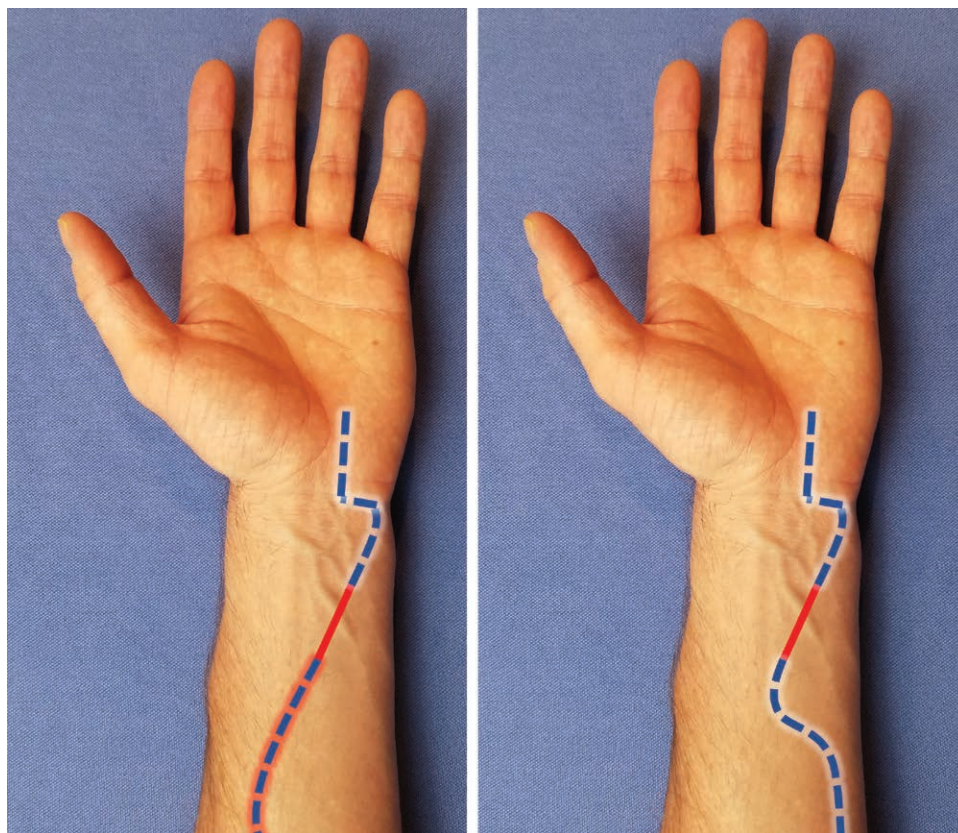


Fig. 8. Many surgeons are familiar with a forearm fasciotomy incision that creates a large, rounded, ulnarly based flap of forearm skin. We favor a more ulnar, longitudinal incision when possible.

is more likely to expose the FCU than the other flexor tendons should the incision gap. The FCU's distal muscle belly will support a skin graft or granulate, whereas the bare FDS tendons will not.

With lacerations at or near the wrist flexion crease, a carpal tunnel release may be necessary to expose and repair the median nerve and to properly identify the flexor tendons. In joining a carpal tunnel incision to the patient's laceration, the palmar cutaneous branch of the median nerve should be avoided (Fig. 9).

Dissection

Start in normal tissue, either slightly proximally in the forearm or distally in the carpal tunnel. Work toward the laceration. Hematoma should be washed away, and blood-filled tenosynovium should be excised. There are potentially 2 major arteries, 2 major nerves, and 12 tendons in play. Laying eyes on the entire zone of injury and each involved structure is more important, at this stage, than precise identification or matching of stumps. Over dissection may distort relationships that are useful in the next step.

Identification of Nerves and Arteries

Frayed nerve and artery stumps may be tagged with vascular clips, anticipating resection of 1–2 ml of tissue to which the clips are applied. Do not ignore the palmar cutaneous branch of the median nerve or the dorsal sensory branch of the ulnar nerve. Large, mixed nerves are grossly

similar in appearance to tendons, but on close inspection, are more cylindrical and different in sheen. Fascicles at clean, cut ends of the median and ulnar nerve are evident.

Tendon and nerve ends have been sutured together by mistake.³ We assume this devastating error occurs in the setting of limited exposure, poor lighting, and a bloody surgical field.

Tendon Matching, Repair, and Inventory

Sew the flexor tendons as you go. In other words, once the ends of the deepest tendons can be matched, repair them. Although it is possible to identify and tag each stump before suturing, this is tedious and results in numerous tagged tendons, which then have to be re-matched! Start by identifying the proximal stumps of the flexor pollicis longus or FDP. Pull potential distal matches and observe the digits. Stump caliber and the obliquity of lacerations may assist with matching.

Perform each repair. Epitendinous sutures are required in Zone 2 to prevent adhesions to and binding within the flexor tendon sheath. There are no true sheaths in forearm, therefore Kessler or figure-of-8 3-0 polyester (eg, Ethibond) stitches are expedient. Although suturing should be meticulous, some bulging at the repair sites is acceptable.

After the deep FDP and flexor pollicis longus tendons are repaired, the FDS tendons and FCR tendon may be addressed. Knowledge of cross-sectional anatomy of the

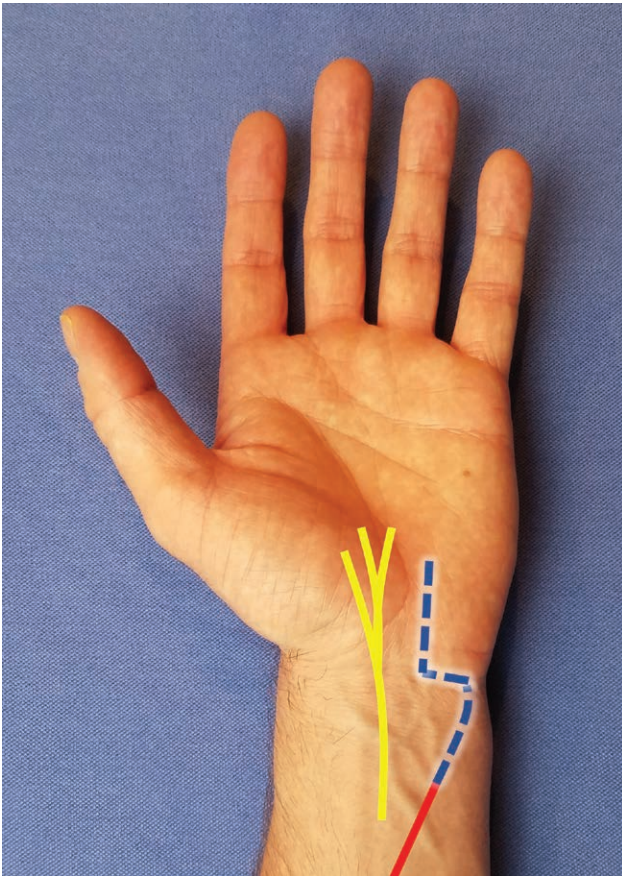


Fig. 9. In joining a carpal tunnel incision to the patient’s laceration, the palmar cutaneous branch of the median nerve should be avoided.

FDS tendons in the carpal tunnel, that is, the superficial location of the ring and long finger FDS tendons, aids in matching. Suture of the FCU should be delayed, for the sake of exposure, if the ulnar nerve and artery require repair.

If present, the palmaris longus tendon should be repaired, anticipating that it may be used as a donor tendon in the future. In the unlikely event that the palmaris longus crosses a wound to be skin grafted, the tendon may be resected.

An inventory should be kept on the surgical drapes or card from a sterile gown. If you take a cell phone picture of this inventory, the status of each forearm structure, for example, “OK,” or “repaired,” may be conveniently included in the operative report. This careful documentation is valuable for the surgeon and hand therapist postoperatively (Fig. 10).

Nerve Repair

Hemorrhagic or frayed nerve ends should be resected, taking care not to create an irreparable gap. A clean, perfectly transverse neurectomy is difficult to make. A piece of sterile glove or Esmarch bandage may be wrapped around the nerve stump and held tightly with a hemostat. This stabilizes the fascicles while they are cut. The wrist

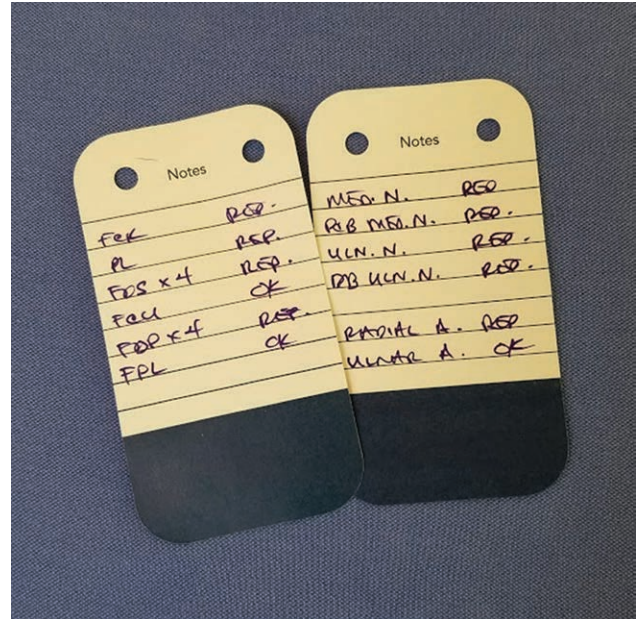


Fig. 10. Careful documentation is valuable for the surgeon and hand therapist postoperatively.

Table 1. Ten Tips to Simplify the Spaghetti Wrist

1. Use an H-shaped, T-shaped, or predominately ulnar incision. Consider a carpal tunnel release to identify distal structures. Begin dissection in normal tissue.
2. Wash away clotted blood and excise bloody tenosynovium.
3. Identify structures based on anatomic principles. Avoid overdissection that distorts normal relationships.
4. Tag nerves and arteries with vascular clips for identification.
5. Do not ignore the palmar cutaneous branch of the median nerve or the dorsal branch of the ulnar nerve.
6. Begin with the deepest tendons and sew as you go. The FCU may be temporarily left unrepaired for access to the ulnar nerve and artery.
7. Next, repair nerves while the tourniquet is still inflated. Use blood vessels running with each nerve and fascicle shape to orient repairs.
8. Place microsurgical clamps on the arteries, and deflate the tourniquet. Repair both the radial and ulnar artery if possible.
9. Do not forget to repair the FCU tendon!
10. Close the skin if possible. Skin grafts may be used to avoid constriction.

FCU, flexor carpi ulnaris.

should be positioned in neutral during nerve coaptation. A tension-free repair should be possible if a single 8-0 nylon epineural stitch approximates the stumps. If tension-free nerve repairs cannot be performed with the wrist in neutral, nerve grafts should be considered.

An attempt should be made to repair cut nerves so that they match on cross-section. Vasae nervorum may be lined up, as may the fascicles of each stump. Individual fascicular repair is difficult and of no proven benefit.⁴ Circumferential epineural stitches are placed under magnification.

Do not forget to repair the palmar cutaneous branch of the median nerve and the dorsal sensory branch of the ulnar nerve.

Arterial Repair

Ideally, the previous steps are accomplished in less than 2 hours. At this point, the tourniquet is deflated.

Some hand surgeons worry that a single-artery hand may become cold-intolerant. There is little evidence to support this suspicion and some evidence to the contrary.⁵ The authors still advocate repair of both major arteries. Much of the effort to repair a single artery involves microscope set up. Once the microscope is in place, a second arterial repair adds little time to the operation.

If both the radial and ulnar arteries are cut, and the hand is dysvascular (which is not always the case), both arteries should be repaired. This will save the hand if one of the repairs clots. Arterial repair is done under the operating microscope with 8-0 nylon suture.

Once the ulnar nerve and artery are repaired, do not forget to repair the FCU tendon.

Skin Closure

Close the skin if possible. Any residual wound should be prepared for a split-thickness skin graft. Muscle will accept a skin graft. Tendon, particularly without paratenon, will not. If the FCR tendon is exposed, as is often the case, underlying FDS muscle may be drawn over and sutured above it. Split-thickness skin grafting may be undertaken immediately; however, use of a vacuum sponge may permit delayed closure or result in decreased area to be grafted.

Persistently exposed tendons are a particular problem. An attempt at coverage with a collagen dermal substitute is reasonable if the area of exposed tendon is small and if this area is surrounded by particularly healthy tissue. Flap coverage is otherwise required.

A dorsal plaster splint should be used to hold the wrist in neutral, the metacarpophalangeal joints in 90 degrees of flexion, and the interphalangeal joints straight.

Monitoring

The vascular status of the hand after arterial repair may be monitored with pulse oximeters placed on the digits. This allows untrained observers to screen for problems and to call for a skilled examination if necessary.⁶

REHABILITATION

Flexor tendon lacerations in the wrist and forearm need not be moved early like flexor tendon repairs in Zone 2. Whereas extended immobilization would create debilitating adhesions in the fingers, there are no sheaths in the forearm for tendons to attach to. Three weeks of splinting allows sufficient healing for the patient to begin a rehabilitation protocol based on active, unresisted range of motion. Forceful gripping should begin 3 months after surgery.

Dorsal splints that hold the metacarpophalangeal joints in flexion during the first 6–8 weeks of recovery ease tension and prevent full extension of the repaired tendons. Although perhaps counterintuitive to patients and hand therapists, this technique creates tenodesis at the metacarpophalangeal joints and prevents clawing in the setting of median and ulnar nerve lacerations.

Synchronous, full flexion of the digits should be prioritized over full extension.

Nerve regrowth occurs at roughly a millimeter a day. Age and smoking status are predictors of neurologic recovery and patients should be counseled accordingly.

OUTCOMES AND COMPLICATIONS

Patients should expect a functional but imperfect recovery.^{1,7–15} Recovery of ulnar innervation is less predictable than that of the median nerve.^{1,7–9} Adults often achieve protective sensation at the finger tips but loose forceful intrinsic muscle function. Compartment syndrome, possibly as a result of occult bleeding, and loss of arterial patency are early risks. Stiffness and neuropathic pain are notable long-term problems as is cold intolerance. Cold intolerance, when it does occur, likely has more to do with neurologic rather than vascular injury.^{5,16,17}

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