An Evidence-Based Approach to Flexor Tendon Laceration Repair

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The Maintenance of Certification module series is designed to help the clinician structure his or her study in specific areas appropriate to his or her clinical practice. This article is prepared to accompany practice-based assessment of preoperative assessment, anesthesia, surgical treatment plan, perioperative management, and outcomes. In this format, the clinician is invited to compare his or her methods of patient assessment and treatment, outcomes, and complications, with authoritative, information-based references.

This information base is then used for self-assessment and benchmarking in parts II and IV of the Maintenance of Certification process of the American Board of Plastic Surgery. This article is not intended to be an exhaustive treatise on the subject. Rather, it is designed to serve as a reference point for further in-depth study by review of the reference articles presented. (Plast. Reconstr. Surg. 127: 1, 2011.)

CLINICAL SCENARIO

A 25-year-old, working, single mother of two is referred to you 2 weeks after she has lacerated the profundus tendon and digital nerves in zone 2 (under the A4 pulley) of her dominant index finger. She cannot afford to miss any of her hard work on an assembly line. What is the best evidence to guide you in the management of her condition?

Most surgeons practice flexor tendon repair management based on what they learned in training tempered by life experience with complications and personal outcomes. The purpose of this article is to provide a summary of the best available evidence on flexor tendon repair that, when combined with individual clinical expertise, can assist the surgeon in the continuing evolution toward better outcomes.

METHODS FOR IDENTIFYING EVIDENCE

A literature search of PubMed, the Cumulative Index to Nursing and Allied Health Literature, and the Cochrane Library was performed to obtain the best available evidence on flexor tendon repair, with emphasis on preoperative assessment, anesthesia/analgesia, antibiotic, and deep venous thrombosis prophylaxis, treatment, and outcomes. The following search terms were combined as appropriate, and PubMed MeSH terms were used when available: “flexor tendon,” “injuries,” “laceration,” “tendon injuries,” “hand,” “fingers,” “digits,” “zones,” “diagnosis,” “preoperative assessment,” “sensation,” “radiography,” “ultrasonography,” “treatment,” “therapy,” “repair,” “surgery,” “incision,” “premedication,” “antibiotic prophylaxis,” “venous thrombosis,” “DVT,” “deep vein thrombosis,” “prevention,” “prophylaxis,” “control,” “rehabilitation,” “postoperative movement,” “total active movement,” “TAM,” “early movement,” “mobilization,” “outcome,” “complications,” “hematoma,” “surgical wound dehiscence,” “surgical wound infection,” “rupture,” “adhesion,” and “pain.” The initial search was limited to human studies that were published from 1999 to 2009 and indexed as meta-analyses, randomized controlled trials, clinical trials, or comparative studies; however, additional references were included if deemed necessary for discussion. Studies were excluded if the full text was inaccessible or of non-English language, as the study quality could not be evaluated. Relevant studies were appraised for quality and validity according to criteria published by the Critical Appraisal Skills Programme1

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and assigned a level of evidence with the American Society of Plastic Surgeons Evidence Rating Scale for Therapy (Table 1). Levels of evidence are indicated throughout the text. Evidence ratings were not assigned to studies with inadequately described methods and/or worrisome biases or to references included for discussion purposes only (e.g., narrative reviews).

### EVIDENCE ON ANESTHESIA

Although the majority continue to use general or block anesthesia, there is a new approach with wide-awake flexor tendon repair that deletes all of the risks and inconveniences of sedation and general anesthesia. This technique uses locally injected lidocaine and epinephrine for anesthesia and hemostasis (no tourniquet) in unsedated patients who can actively move the tendon repair comfortably while the surgeon watches and makes adjustments before the skin is closed (Level IV Evidence). Proponents claim that the gap formation that causes tendon bunching in the suture with active movement can be seen by the surgeon during the operation and corrected before the skin is closed, thereby decreasing the risk of rupture. The surgeon can also make sure that the repair fits through the pulleys with active movement before closing the skin. Although the wide-awake approach to flexor tendon repair clearly eliminates the risks of general and sedation anesthesia, the evidence for the use of this technique remains at level IV at this time.

Tüzün et al. used botulinum toxin type A to weaken the flexors in children younger than 6 years, with good results (Level IV Evidence). This approach paralyses the flexor tendons temporarily to decrease the risk of rupture.

### EVIDENCE ON SURGICAL TREATMENT PLAN

Strickland recommends what is practiced by most, which is that both tendons in zone 2 injuries be repaired. However, Hwang et al. have shown in a cadaver study that repairing the superficialis increases the work of gliding over repairing profundus alone, and repairing only one slip of the superficialis may be beneficial in reducing the work of flexion. In addition, Tang showed that there was no difference in total active movement in repairing both the profundus and the superficialis in zone 2 versus repairing the profundus alone, and in fact those in the group that had both tendons repaired ended up having more reoperations because of adhesions. There is still no better evidence than level V to guide the decision of what to do with the superficialis in zone 2 injuries.

There is abundant experimental work that shows that gapping and therefore possibly rupture may be decreased by adding two or more additional strands to a two-strand repair. Interestingly, a 2008 randomized controlled trial by Navalı and Rouhani showed no difference in zone 2 flexor tendon repair in young children in a four-

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<td>High-quality, multicenter or single-center, randomized controlled trial with adequate power; or systematic review of these studies</td>
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<td>Expert opinion; case report or clinical example; or evidence based on physiology, bench research, or “first principles”</td>
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strand compared with a 2-strand repair (Level II Evidence). A 2008 study retrospectively compared a six-strand Lim/Tsai repair to a two-strand Kessler repair (Level III Evidence). Both groups were treated with a combination Kleinert/Duran protocol, but the six-strand group also added place and hold to the postoperative therapy. The six-strand/place-and-hold group obtained better total active movement and grip strength results. Osada et al. prospectively assessed 21 consecutive patients treated with six-strand locking repairs and early active movement and showed excellent results, with no ruptures (Level IV Evidence). There are other good result reports of six-strand and eight-strand repair. Although many surgeons have moved to repairs using four or more strands, there is still no high-level evidence to prove that this is justified.

Taras et al. showed in cadaver tendons that a 4-0 suture was 66 percent stronger than a 5-0 suture, a 3-0 suture was 52 percent stronger than a 4-0 suture, and a 2-0 suture was 51 percent stronger than a 3-0 suture. Several cadaver and animal studies and clinical studies have suggested that peripheral epitenon suture, usually of 6-0 nylon, increases the smoothness of the repair, increases the strength of the repair from 10 to 50 percent, and may decrease gapping and therefore decrease rupture. Papandrea et al. advocate the epitenon suture—first technique.

Locking sutures have been shown to have advantages over grasping sutures in cadavers. Locking suture configurations tighten around bundles of tendon fibers with tension, whereas grasping loops do not tighten around but pull through tendon fibers and distract with tension. There is experimental evidence that longer core suture purchase length (1 cm) is superior to shorter purchase length (0.4 cm) with an optimal length of 0.7 to 1.0 cm.

Although most continue to use nonabsorbable braided core sutures, a 2008 British study compared absorbable and nonabsorbable core sutures. Each group had the same rupture rate of 2 percent (Level III Evidence).

FiberWire (Arthrex, Inc., Naples, Fla.) is a new high-strength tendon suture that shows promise but still has to be clinically proven superior. A 2005 study by Su et al. compared the Teno Fix (Ortheon Medical, Columbus, Ohio) device to a four-stranded cruciate repair (Level I Evidence). The rupture rate was 18 percent with the sutures and 0 percent with the Teno Fix. One Teno Fix device migrated. The movement outcomes were the same in both groups.

Suture anchor has been shown to provide results as good as those achieved with the pullout button method, but with greater patient satisfaction, sooner return to work, and less morbidity (Level II Evidence). Another 2009 study reported good results with zone 1 injuries with drill hole sutures to distal phalangeal bone (Level IV Evidence).

In summary, other than the use of suture anchor compared with the pullout button method (Level II Evidence), there is no high-level evidence to guide the current belief (based almost exclusively on animal and cadaver studies) that larger locked sutures of stronger material supported by epitenon sutures are better. Absorbable sutures may be equivalent to nonabsorbable sutures (Level III Evidence).

The evidence on repairing the flexor tendon sheath remains contradictory and largely confined to animal work. One of the only human studies is a study in 106 children divided equally into two groups that showed superior movement results in the 53 children whose sheaths were patched with vein grafts (Level III Evidence).

A study with glycosaminoglycan gel (ADCON-T/N) to decrease adhesions showed that there was a shorter time to achieve total active range of motion, but that there was no difference in the total range achieved (Level II Evidence). However, the study was discontinued because of a 10 of 30 case rupture rate with glycosaminoglycan gel. In contrast, another study with this chemical found no increase in rupture rate, and did show an improvement in proximal interphalangeal joint flexion outcome (Level II Evidence). A study by Guo et al. reported that topical application of 5-fluorouracil on freshly repaired tendons provided better outcomes of movement. Despite the high level of evidence of these studies, the use of topical agents remains experimental.

There are three basic types of postoperative early movement regimens: (1) rubber band passive flexion/active extension started by Kleinert et al., (2) passive flexion and extension pioneered by Duran and Houser, and (3) early active movement as advocated by Becker et al.

The only Cochrane review on flexor tendon injuries examined the rehabilitation side of the issue (Level II Evidence). They concluded that there was insufficient evidence from randomized controlled trials to define the best mobilization strategy. There is a trend toward increasing early active movement protocols.

In 1991, Gelberman et al. reported good results with a continuous passive motion device (Level II
Evidence.49 Strickland and Glogovac showed superior total active movement results with early passive movement compared with immobilization.50 A 1989 study showed that dynamic splinting with early movement in flexor pollicis longus repairs produced better thumb movement than immobilization and static splinting.51 Becker et al. produced one of the first series of early active movement, which produced 70 percent good to excellent results, with a 10 percent rupture rate.45 A prospective case series of 52 patients with zone 5 (wrist and forearm) tendon lacerations obtained 90 percent good or excellent results with an active movement protocol.52 A 2005 study showed good total active movement results, with a 6.5 percent rupture rate with an early protected active flexion protocol (Level IV Evidence).53

A 2009 study compared a Kleinert/Washington (controlled active group) regimen to a Duran (controlled passive group) type of postoperative movement (Level II Evidence).54 They found that the controlled active group achieved better results in Buck-Gramcko total active movement and Disabilities of the Arm, Shoulder and Hand scores. This study with high-level evidence is the first to show superiority of early active versus early passive movement.

Motor imagery is a form of postoperative therapy where the patient imagines moving the hand a set number of times during the day though he or she is not actually able to do so. A study has shown this to result in improvement in hand preparation time but no significant difference in total active motion outcomes (Level II Evidence).55 Adolfsion showed that letting patients have unrestricted movement at 8 weeks following tendon repair fared as well as those held back 10 weeks (Level II Evidence).56

EVIDENCE ON POSTOPERATIVE OUTCOMES

A retrospective 2005 study showed that the outcome of sensation after digital nerve repair was the same in patients who had isolated digital nerve injuries and were immobilized for 3 weeks compared with those who had concomitant flexor tendon repairs and were immobilized for only 4 days (Level III Evidence).57 The authors found no significant advantage in prolonged immobilization of nerve repairs.

A review of 23 patients who ruptured their flexor tendon repair (rupture rate of 4 percent) attributed half of the ruptures to unfortunate postoperative accidents (Level IV Evidence).58 There were no other identifiable causes of the ruptures. In a prospective study following 233 patients with zone 1 and 2 injuries and an early active movement program, the rupture rate was 5.8 percent in fingers and 16.6 percent in thumbs (Level IV Evidence).59 A recent review reported that repair ruptures are generally 4 to 10 percent for zone II finger flexors and 3 to 17 percent for the flexor pollicis longus tendon.60 A 1992 study from seven Swiss centers reported the rate of tenolysis to be 33 percent.61

RECOMMENDED TREATMENT FOR CLINICAL SCENARIO

When practicing evidence-based medicine, the surgeon should consider the strength of the available evidence and integrate the evidence with his or her clinical expertise and the patient’s values and preferences to develop an appropriate treatment plan. The treatment plan below is an example of how the surgeon might use the evidence to care for this particular patient.

Based on the available evidence, our 25-year-old single mother would likely be best treated with repair of the nerves (Level III Evidence) and the profundus tendon. She should be treated with an early protected active movement protocol (Level II Evidence).54 She should be allowed to return to work at 8 weeks after repair (Level II Evidence).56

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REFERENCES


AQ1: AUTHOR—Name and city/state location of manufacturer of Teno Fix correct as supplied? If not, please supply the correct information, per Journal style, or use a generic product name throughout.