Invited Personal Review

INDICATIONS, METHODS, POSTOPERATIVE MOTION AND OUTCOME EVALUATION OF PRIMARY FLEXOR TENDON REPAIRS IN ZONE 2

JIN BO TANG

From the Department of Hand Surgery, The Hand Surgery Research Center, Affiliated Hospital of Nantong University, Nantong, China

Abstract

In recent years, our unit has put into practice of flexor tendon repairs a number of novel concepts, which we hope address some critical difficulties in primary flexor tendon repairs in Zone 2, thus pointing the way towards predictable surgical outcomes. In this article, I present my practical views on indications, techniques, post-surgical treatment and outcome measures, and describe our methods of sheath-pulley release, tendon repair, postoperative motion and outcome evaluation.
Journal of Hand Surgery (European Volume, 2007) 32E: 2: 118–129

Keywords: Flexor tendon, Tendon injury, Sheath and pulleys, Repair surgery, Tendon mobilisation, Outcome evaluation

The advent of primary flexor tendon repairs within the synovial sheath region should be credited to those pioneers, such as Verdan (1960) and Kleinert et al. (1967), nearly half a century ago. Prior to that, over a long period of the previous half century, primary tendon repair was not advocated and surgeons followed Bunnell's advice to remove the tendons entirely and graft in new tendon (Bunnell, 1918, 1922). The reports of Verdan and Kleinert and his colleagues on primary flexor tendon repairs established that the lacerated digital flexor tendon can be treated by direct end-to-end repairs when wound conditions are favorable. However, most surgeons have noted that the outcomes of primary repairs remain hard to predict, particularly in respect of restrictive adhesion formation and rupture of repairs (Cullen et al., 1989; Elliot et al., 1994; Small et al., 1989; Strickland and Glogovac, 1980; Tang et al., 1994). Over the last two decades, surgeons have tried to identify flexor tendon repairs which yield optimal outcomes consistently. Considerable research and clinical effort has been expended and the number of reports on this subject probably surpasses those on any other single topic in Surgery of the Hand during this period. While the overwhelming number of investigations reflects the elaborate nature of the basic science and clinical practice regarding digital flexor tendon repairs, the volume of work also indicates that a path leading to a satisfactory and predictable treatment outcome has not yet been identified.

In recent years, our unit has put into practice a number of novel concepts which we believe may ensure more predictable surgical outcomes and help to address some critical difficulties in primary flexor tendon repair. We hope that they eventually point the way towards optimal flexor tendon repairs. In this article, I present our practical views on indications, techniques, post-operative mobilisation and outcome measures.

INDICATIONS

"Clean-cut" wounds, the simplest clinical situation associated with digital tendon lacerations, are a prime indication for primary flexor tendon repair. I consider a wound to be such when cut cleanly and tidily, usually as a single transverse, or oblique, wound in the fingers or distal palm, and produced by a knife or a piece of glass. The cut is also "clean" in terms of minimal potential for contamination and infection. Anatomically, the tendon(s) is only "severed", and without tissue defect. The cut tissues may even align well. This is the best indication for primary repair, with the greatest likelihood of relatively uncomplicated repair, rehabilitation and satisfactory outcome. Such wounds are very often accompanied by divisions of the digital neurovascular structures, which does not contraindicate primary repair of the tendons.

Crush injuries to a very limited segment of the fingers, or palm, produce untidy skin and subcutaneous injuries and tendon wounds. It is accepted that such wounds are also good candidates for primary repairs, because the soft tissue wounds and tendons can be made "similar" to those associated with a clean-cut wound through debridement of nonviable tissues and direct wound closure. However, these injuries have a greater potential for contamination. Primary tendon surgery is possible, although more difficult than with a truly "clean-cut" wound. Phalangeal fractures are rarely associated with a clean-cut flexor tendon laceration, but can become part of a crush injury. A simple and stable fracture in the phalangeal shaft can be securely fixed internally and, so, presents no contraindication to primary tendon repair.

The borderline indications for primary repairs have been less thoroughly addressed and I have seen no clinical investigations devoted solely to this topic. Nevertheless, it is in such cases that we must explore

the limits of the indications for primary repair. Below, I outline five clinical situations representing borderline indications for primary tendon repairs, along with some considerations used in the decision making process as to whether to undertake primary surgery.

(1) *Localised soft tissue injuries*: Crush, or compression, injuries on the palmar aspect of the fingers sometimes lead to localised soft tissue defects. The underlying flexor tendons may present with a short traumatic defect, or such a defect arises after debridement of nonviable, ragged tendon tissue. I deem this situation to include no contraindications to primary repair if the soft tissue defect is less than $\frac{1}{3}$ the length of the fingers and the tendon loss is less than 1.5 to 2 cm. The soft tissue can be repaired easily with a local or free flap transfer and the tendon is repaired by direct end-to-end suture. However, a tendon with a defect length close to 2 cm is hard to pull together, sometimes. In this case, intramuscular tendon lengthening through a forearm incision may release the tension (Le Viet, 1986). Direct end-to-end suture of the tendon should be accompanied by a procedure to reduce the tension on the tendon when surgeons or therapists are less experienced with dealing with tendons with a defect, otherwise the repair may be ruptured easily upon starting active digital mobilisation. Flap transfer provides fresh and vascularised tissue coverage, not very different from the original digital subcutaneous tissue, and early mobilisation of the tendon is still possible under the flap.

(2) *Injuries including a simple and stable fracture*: As mentioned above, a simple, stable fracture in the phalanx is by no means a contraindication to primary tendon surgery. What are seen more frequently, however, are tendon injuries associated with fractures involving joints in more than one phalanx, with crush, or abrasion, of the overlying soft tissues. These skeletal injuries are contraindications to primary tendon repair, because fractures involving joints tend to be unstable, the soft tissue wounds are always contaminated and early postoperative tendon mobilisation is difficult, or not feasible. Fractures in the shafts of more than one metacarpal bone may sometimes accompany a cut digital flexor tendon. These injuries do not preclude primary tendon surgery, providing the fractures are simple, limited to the shaft and do not involve the joints. Internal fixations in the palm with mini-plates, screws, or K-wires usually ensure a stable reduction, but early postoperative exercise may have to be less aggressive.

(3) *Rupture of tendon repairs*: Ruptures of primarily repaired tendons have been noted in almost all case series incorporating early active finger mobilisation. However, the first report exclusively considering repair of ruptured tendon has only just been published (Dowd et al., 2006). I approach the ruptured tendon repair as I would a primary tendon repair. Tendons need to be trimmed. About half, or more than half, (if not the entire) segment encompassed by the original sutures should be trimmed off, because the ends are softened and ragged and this decreases the holding power of the subsequent re-repair. The length of tendon segments that I trim off is about 0.8 to 1.0 cm (0.5 cm or less on either end). This amount of shortening is of no biomechanical consequence to the flexor digitorum profundus (FDP) tendon, even if the tendon had been trimmed by a similar amount previously at the initial surgery. In my experience, the shortening that the FDP tolerates can be up to 1.5 to 2 cm. The ruptured flexor digitorum superficialis (FDS) tendon should be removed. I find re-repair of both tendons impractical, and shortening of the FDS, particularly within Zone 2, is mechanically disadvantageous, because the structures and gliding direction of the FDS tendon varies greatly and the two parts of the FDS tendon are hard to match after loss of a tendon segment. The digital sheath system, both the parts mainly consisting of synovial sheath and those which are dense annular pulleys, is usually less elastic, narrow and inclined to collapse after the primary repair ruptures. Rupture of a repair seen within one month after the initial repair is always worth an attempt at re-repair. However, after one month from primary repair, re-repair is rarely indicated as ruptured tendons one month after primary surgery are likely to be surrounded by adhesions and their healing potential is limited, particularly if the tendons are repaired under increased tension.

(4) *Delayed repairs*: I have found no clinical investigation which actually validates the textbook concept of "the best time" for primary repairs. All estimates of the "best time" to carry out primary flexor tendon repair suggested so far have been empirical. I do not have a rigid "best" time frame in mind, as previous suggestions regarding the timing of primary repair are not consistent and may not be imperative. The ideal situation is that a patient with digital flexor tendon lacerations is brought into the clinic soon after injury, surgery begins within a few hours and an experienced surgeon is readily available. The tendon should not be repaired primarily by an inexperienced surgeon. Rather, the tendon repair can be delayed until an experienced surgeon is available. My preferred period of deliberate delay is 4 to 7 days, when the risk of infection can be properly addressed and oedema has reduced substantially. My clinical impression is that treatment outcomes after delay for such a short period are almost identical to those associated with primary repair promptly after the trauma. Upon re-opening of the wound, the cut tendon ends still appear fresh and no collapse or fibrosis of the sheath is seen. The tendons can be treated as if they were freshly cut. However, when the surgery is postponed further beyond that period, the tendon ends may be rounded, with varying degrees of adhesions present, and the elasticity of the sheath is likely to be reduced, making repair more difficult. Although it is generally considered that a delay of over one month would rule out direct end-to-end repair surgery, surgeons may need to pay attention to a largely forgotten, but potentially