Current Practice of Primary Flexor Tendon Repair
A Global View

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Lacerated flexor tendons, especially those in the digital sheath area, were largely not considered candidates for primary surgical repair in the first half of the twentieth century. Primary repair of the flexor tendon in the digital sheath area was established in the 1970s to the 1980s, following conceptual changes brought about by pioneers such as Claude Verdan and Harold Kleinert in the 1960s. Although indications for primary repair are similar to those described decades ago, the surgical techniques, concepts regarding treatment of sheath and pulleys, and methods of postoperative care changed considerably. The ultimate goals remain to achieve close-to-ideal functional restoration and predictable clinical outcomes.

KEYWORDS
- Flexor tendon
- Primary repair
- Strong surgical repair
- Core sutures
- Flexor pulley
- Pulley venting
- Surgical techniques
- Rehabilitation

KEY POINTS
- Primary or delayed flexor tendon repairs in the hand have become standard practice over the past 30 years; direct end-to-end repair in the digital sheath area using a multistrand core suture (4-strand, 6-strand, or 8-strand repair) has become widely adopted over the last 10 years.
- Although repair methods vary, basic principles include use of strong surgical repairs, slightly higher tension over the repair site, and ensuring sufficient core suture purchase (1.0 cm).
- 3-0 or 4-0 sutures are used for making core sutures, and 6-0 sutures are used for peripheral suturing. A strong core suture (6-strand or greater), made with proper tension over the repair site, may circumvent the use of peripheral sutures.
- In the past 10 years, the policy for preservation of the pulleys has been revolutionized. A part of the A2 pulley can be incised to free tendon motion, or the entire A4 pulley may be incised to allow repair and tendon movement if other pulleys are intact.
- Combined active-passive motion regimes are the mainstay of postoperative care, but the details of exercise protocols vary greatly. Rubber-band traction has been almost abandoned, and purely passive motion has declined in popularity.
This article reviews the evolution of treatment methods and provides global views and details of the surgical methods and rehabilitation regimes used in major hand units across the world. The surgical principles and key technical considerations underlying these diverse treatment options are also summarized.

CURRENT PRACTICE ACROSS THE GLOBE
United States and North America

Although exact statistical data are not available from members of the American Society for Surgery of the Hand (ASSH), in the last decade there has been a clear technical shift in core tendon repair, from conventional 2-strand core sutures to methods with 4 or more suture strands. The current methods of digital flexor tendon repair in the United States have been developed by units that have spent decades in the development of repair methods.

Mayo Clinic
The current practice is (1) use of a 3-0, low-friction suture material, with a 4-strand high-strength repair; (2) low-friction suture design, such as the modified Pennington, with locking loops; (3) a running epitendinous finishing suture; (4) recourse to pulley trimming, or excision of 1 slip of the flexor digitorum superficialis (FDS) in cases of difficulty in tendon gliding in zone 2; (5) early motion after a few days' delay; (6) starting with a modified synergistic therapy; and (8) progression to active motion as healing progresses.

The preference of Dr Amadio is a modified Pennington suture design for the core suture, because it locks the loops definitively by coming out of the tendon dorsally. He uses 2 such core sutures, made with either 3-0 or 4-0 TiCron, depending on tendon size. Other surgeons use double Tsuge sutures, made with 3-0 or 4-0 Supramid, with 1 on each side of the tendon, being sure to keep the surface loops lateral, to minimize friction. Some others prefer the modified Kessler repair.

The peripheral sutures used at Mayo commonly are simple running sutures of 6-0 nylon or Prolene, although Dr Amadio does prefer a running locking suture. The Lin locking suture is not used clinically, because it is difficult to perform and it causes more friction than other peripheral sutures.

There is no standard rehabilitation protocol used by all surgeons following tendon repair at the Mayo Clinic, and the specific details depend on the nature of the injury. They see many complex injuries in their practice, which receives referrals from a large agricultural region. Some of these patients return home for aftercare, and trained hand therapists may or may not be readily accessible. For a clean-cut injury in zone 2, the patient is initially placed in an extension block splint with the wrist and metacarpophalangeal (MCP) joints flexed. The Mayo Clinic no longer uses rubber-band (Kleinert) traction to the finger tips.

Passive motion is typically started using a modified synergistic protocol combined with passive joint mobilization within 3 to 5 days after surgery, and this progresses to place-and-hold exercises once the finger joints are supple. In this protocol, the patient comes out of the splint to actively flex the wrist and extend the fingers simultaneously. Then, while keeping the MCP joints extended, the interphalangeal (IP) joints are flexed (for the first few days passively, then later actively) and the wrist is actively extended. The patient comes out of the splint for exercises, usually several times each day. Usually by 3 weeks the patients have begun gentle active-motion exercises, including both fist and hook grip positions. The splint can usually be discarded by 6 weeks, and the patient can begin light resistive exercises, progressing to heavier use gradually over the next 6 weeks. Most patients are dismissed from care by week 10 or 12 if they are doing well. If not, other modalities such as ultrasound or stretching may be added.

Washington University (St Louis, MO)
The current practice in this unit is as follows: (1) use of a 3-0 or 4-0 low-friction suture material such as a looped braided caprolactam, with an 8-strand Gelberman-Winters core suture technique; (2) placement of a single knot within the repair site; (3) a simple running epitendinous suture of 5-0 or 6-0 Prolene placed deeply across the tenorrhaphy site; (4) early motion using a synergistic protocol combining wrist flexion with active finger extension against a dorsal block, and finger flexion (passive, with a gentle active component) combined with active wrist extension.

At Washington University, surgeons prefer to use a Gelberman-Winters core suture technique, using the 3-0 or 4-0 braided caprolactam suture (Supramid) for the following 2 reasons: first, it allows for the passage of 2 suture strands with the single passage of the needle, and, second, the tapered design of the needle minimizes damage to the tendon during core suture insertion. If an 8-strand core suture is not possible because of small cross-sectional tendon area (such as at the A4 pulley or distal to it, or in the small finger), then a 4-strand modified Kessler pattern is used followed by an epitendinous suture. Based on the data of Diao and colleagues and Nelson and colleagues, they prefer to use a simple running
epitendinous suture of 6-0 Prolene placed 2 mm from the tenorrhaphy site and also deeply within the tendon.

They routinely use a synergistic wrist protocol for patients who are able to participate actively in postoperative therapy. A hinged brace is used, which allows simultaneous synergistic motion of the digits and of the wrist. This protocol is based on experiments done in a clinically relevant in vivo canine model, which showed that this protocol provides a lower level of proximal musculotendinous force (and therefore less gap formation) and also an increased level of intrasynovial repair site excision (so as to minimize repair site adhesions). For patients unable to participate reliably in such a protocol or patients with isolated flexor pollicis longus tendon (FPL) lacerations, a modified Duran place-and-hold protocol is used.

Passive motion is typically started using a modified synergistic protocol combined with passive joint mobilization within 2 days following repair. The initial focus is on passive motion and edema control by means of digital wraps. The progression is similar to that described for the Mayo Clinic. The splint is discontinued once the repair site has accrued enough strength to withstand active-motion therapy (around 6 weeks). Resisted motion and strengthening do not begin until 10 to 12 weeks have elapsed from the time of repair.

Hospital for Special Surgery (New York)

Surgeons (Drs Lee SK and Wolfe SW) at Hospital for Special Surgery use a cross-locked cruciate as the core suture with a braided nonabsorbable suture such as 3-0 or 4-0 FiberWire (Arthrex, Naples, FL) or 3-0 or 4-0 Ethibond. The suture span (middle of the X from the lacerated end of the tendon) is 10 mm (7 mm minimum) for optimal biomechanical performance. This span is followed with a circumferential suture with either the interlocking horizontal mattress suture method with 6-0 Prolene or a running lock suture with a suture span of 2 mm (Fig. 1A, C). The combination repair of cross-locked cruciate interlocking horizontal mattress (CLC-IHM) has an ultimate strength of 111 N, 2-mm gap force of 90 N, and only a 5% increase in work of flexion, the lowest increase in work of flexion reported to date.

The CLC-IHM repair can be technically demanding, but the benefits of a strong repair with minimal bulk are worth the effort. The core suture should start in the center and dorsally; this ensures that the suture knot will not protrude out of the repair site and catch on pulleys. The tendon ends must be perfectly opposed before starting the suturing, which can be accomplished with 25-gauge needles placed in both tendon ends approximately 15 to 20 mm from the cut ends of the tendon. Once the second cross lock is placed and tightened, the tendon ends hold their position, meaning that the ends cannot be overopposed, which would bulge the tendon ends otherwise. If the tendon ends are gapped at the beginning of the suture process, the tendon ends cannot be opposed when using a braided suture. Each cross lock should be cinched tightly like shoestrings as the surgeon proceeds. The core suture knot has 6 throws/hitches (surgeon’s knot plus 4 half hitches). Use of a circumferential suture is imperative to prevent gapping. Dr Lee prefers the interlocking horizontal mattress suture; Dr Wolfe uses a running lock method.

With this repair method, patients can be moved early. The strength of the repair in an early motion protocol increases from time zero; only when tendons are immobilized postoperatively do they get weaker temporarily before getting stronger (the softening effect). Based on the work of Cao and Tang, we strive to have patients start motion at 4 to 5 days. Synergistic hand motion (wrist flexion with active digital extension, wrist extension with active fist), followed by tip-to-palm place and hold, hook fist positioning, and intrinsic plus exercises are key exercises. The patients commence these exercises at 4 to 5 days. Blocking exercises start at 4 weeks, strengthening at 8 weeks, unrestricted regular activity at 6 months, and contact sport at 9 months.

Stanford University Medical Center (Palo Alto)

Surgeons (Dr Chang and others) used the epitendinous suture-first method. A continuous epitendinous suture is added with 6-0 nylon, followed by a 4-strand core repair (modified Strickland), consisting of a locking Kessler repair and a 2-strand horizontal mattress suture using 3-0 or 4-0 sutures. The knot of the locking Kessler repair is buried under the tendon surface. The tendon purchase is 2 mm for epitendinous stitches and 1 cm for core stitches. Combined passive and active motion is prescribed for 6 weeks after surgery. The original Strickland repair (4 strands) shown in Fig. 1 is used in some other units.

The increasingly popular wide-awake approach for flexor tendon surgery was developed by Lalonde in Canada. This approach allows intraoperative assessment of tendon gliding and gapping between the repaired ends. Dr Lalonde and colleagues typically use a 4-strand core suture and midrange active motion after surgery.

Australia

The current practice in tendon repair in Australia has been in parallel with international experience,
with important local contributions by Walsh, Tonkin, and Sandow, and their associated groups.\textsuperscript{16–20} Although the modified Kessler has been the workhorse in the past, a recent survey in Australia identified that around 80\% of hand surgeons in that country are now using a multi-strand (greater than 2 strands) core repair, most of which are the 4-strand single cross-grasp

Fig. 1. Core suture methods used in different units: (A) modified Pennington suture (lateral view), (B) 4-strand double Tsuge suture. Both (A) and (B) are used in the Mayo Clinic. (C) Eight-strand Gelberman-Winters suture used in Washington University in St Louis (MO). (D) Cruciate repair used in the Hospital of Special Surgery, New York (NY). The interlocking peripheral suture is also shown. (E) A modified Strickland, a 4-strand repair made up of a locking Kessler repair and a horizontal mattress suture, used in the Stanford University Medical Center. (F) Strickland suture. (B–F) The repair in anterior view.
Modification of the Savage technique (Adelaide repair),\textsuperscript{19,20} The use of a multistrand surgical repair and a fully active-mobilization postrepair protocol has been a standard in several centers. The single cross-grasp 4-stand Adelaide repair was introduced into routine use in several centers in 1994,\textsuperscript{20} and is now a dominant repair technique nationally. The technique of epitendinous repair varies from a simple loop to a stronger Silfverskiold repair, depending on surgeon preference and tendon dimensions.

With the introduction of stronger repairs allied with improved training, there has been a notable reduction in the number of cases needing secondary surgery in Australia. If secondary tendon grafting is required, there has been an increased use of active mobilization in conjunction with single-stage tendon grafting.

**United Kingdom and Other European Countries**

**United Kingdom**

A survey of British Society of Surgery of the Hand (BSSH) members was performed in 2011 to evaluate current practice for primary flexor tendon repair among its members. Sixty-one responded with a 2:1 split between orthopedic-trained and plastic-trained hand surgeons. The number of cases per respondent ranged from fewer than 5 cases per year (in 18 respondents), often the work of individual surgeons, to more than 30 cases per year (in 5 respondents), being either individual surgeons or, in a few instances, groups of surgeons.

Four-strand core sutures were most popular (46 respondents), a 2-strand repair was used by 15, 6-strand repair by 5, and 8-strand repair by 1 surgeon. There was a predominance of double Kessler, Adelaide, and Strickland users. The most popular core suture material was Prolene (31 respondents), followed by braided polyester (23), nylon (9), FiberWire (1), and Polydioxanone (PDS) (1). Twenty-nine used a simple peripheral suture, 17 the Silfverskiold suture, and 10 a locking peripheral suture.

Fifty-nine respondents performed partial A2 and A4 pulley venting, 2 never vented the pulleys, and 6 sometimes vented all of the A4 pulleys. Twenty never closed the sheath, 22 closed part of the sheath, and 6 always closed the whole sheath.

In Bern, a 6-strand Lim-Tsai repair (4-0 looped nylon) followed by a simple running peripheral suture (Fig. 2), is a common way to repair the flexor digitorum profundus (FDP) tendon.\textsuperscript{21,22} Postoperative care consists of pure active, partial active–partial passive, or pure passive motion (with more robust protective immobilization with plaster or splint), depending on the severity of the injuries to the tendon and surrounding tissues, hand and forearm edema, and damage to other structures (such as fractures and soft tissue loss).\textsuperscript{22}

**University of Bern, Switzerland**

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**Verona University, Italy**

The accepted practice for repairing the FDP tendon is a 4-strand core suture with a single knot using a 3-0 or 4-0 nylon suture. This suture consists of 4 parallel strands tied with a single knot embedded between the two tendon ends. There are 4 grasping anchor points in each of the two tendon stumps (see Fig. 2). This 4-strand method was described
by Dubert in Pontault-Combault, France, and also used by Dr Adani in Verona, Italy. The core suture is strengthened by a simple running peripheral suture made with 5-0 or 6-0 nylon, which also prevents impingement of the repair site under the pulleys. In case of sharp lacerations in zone 2, they prefer to repair both FDP and FDS tendons. The FDS is repaired with a 2-strand modified Kessler or with a simple Tsuge loop suture. In cases of complex injuries (eg, replantation or mutilating injuries), only the FDP is repaired.

A protective back slab is replaced with a splint with the wrist in neutral position, the MCP joints flexed about 50°, and IP joints in extension. Five days after surgery, active-motion exercises are started. The splint is maintained for 5 weeks.

In Italy, the FDP tendon injury in zone 1 or distal zone 2 is often treated using the Mantero technique (a pull-out repair over the fingertip). This method has been popular in this country. Early active motion is important in achieving good results with this technique.

**China and Other Asian Countries**

Repair methods for the lacerated FDP tendon have been influenced by the technique of the Tsuge looped suture, though modified Kessler and its 4-strand variants are also popular. In Japan, looped-suture tendon repair dominates as the method of flexor tendon repair. This method of tendon repair (and its variants) is also popular in Singapore and China. However, in mainland China, more variations of tendon repair methods are seen. Hand surgeons use 2-strand, 4-strand, and 6-strand repair methods; repairs using looped sutures and conventional single-stranded suture are also common. Methods at 2 hand centers in the coastal areas of mainland China, and Chang Gung Memorial Hospital in Taiwan are presented later.

**Chang Gung Memorial Hospital**

In this hospital, 4-0 PDS sutures are regularly used for core sutures of the flexor tendon and 6-0 nylon is used for epitenudinous running sutures. Though 4-strand core sutures are most common, 6 strands are used occasionally in the forearm. A part of the A2 pulley or the A4 pulley is vented on the lateral border if necessary to allow tendon gliding after repair. Passive motion is initiated in the first 2 weeks after surgery, followed by protective active motion from 2 to 4 weeks, and active motion after 4 weeks.

At Chang Gung Memorial Hospital, the same repair methods are used for primary tendon repair in replantation surgery as are used primary repair of a simple laceration.

**Nantong University**

The senior surgeons in this unit use a 6-strand repair with looped nylon sutures for FDP or FPL tendon repair, or a 4-strand repair for FDS tendon repair. A part of the A2 pulley or the entire A4 pulley is vented through the volar midline to free gliding of the repaired tendon. The M-shaped 6-strand repair replaced the original triple Tsuge repair because the newer method reduces the number of sutures used and likely simplifies the surgery, although both the earlier method and the current one produced the same clinical outcomes. The FDS is usually not repaired if the site of damage is covered by the A2 pulley. Either 3-0 or 4-0 sutures are used for making the core suture, and 6-0 suture is used for the peripheral suture. Other 4-strand core repairs are also used in repairing the flat FDS tendon or the tendons in the palm and distal forearm.

At Nantong University, patients are instructed to start active extension and midrange active (within or up to one-half to two-thirds range) flexion starting from day 4 or 5. Digital edema is common for...
the first few days and motion of the digits may induce pain and bleeding. Delaying motion for a few days logically would not increase adhesion formation (adhesions do not form in the first week after surgery) and do not increase the chance of joint stiffness, but it does reduce the workload of therapists and discomfort of the patient.\textsuperscript{15,28} In the first 2.5 to 3 weeks, the emphasis is placed on full extension of the IP joints, but active digital flexion is necessary only over the initial one-third to two-thirds of finger flexion range (ie, partial active-motion or midrange active-motion regime).\textsuperscript{26} After 2.5 to 3 weeks, the splint is changed to keep the wrist in a functional position, and range of active flexion is increased (gradually and not against external resistance or excessive internal resistance). A full range of active flexion is encouraged at weeks 4 and 5. The patient actively moves the hand without splint protection after week 6 and returns to normal use in weeks 8 to 10.\textsuperscript{26}

In another unit, the Wuxi Hand Surgery Hospital, the U-shaped (4-strand) core repair is used for simple zone 2 repairs and in repairs associated with replantation (see Fig. 3).\textsuperscript{29,30} The 4-strand repair is supplemented with a variety of robust peripheral sutures (made with 5-0 or 6-0 suture). Combined early active motion without place and hold is the standard method of postoperative care in this unit.

Because of the geographic proximity of Vladivostok in Russia to China, the Korean peninsula, and Japan, the method used at Vladivostok Medical University has an Asian influence. Looped suture lines are commonly used for tendon repair in this unit. Early combined passive-active motion starts a few days after surgery. Research into modification of tendon repair methods is pursued by senior surgeon Dr Alexander Zolotov.\textsuperscript{31}

Table 1 summarizes the current practice in some of the leading hand units. Details of surgical methods and postoperative care about 2 of the units on the list are available separately.\textsuperscript{32,33} No repair ruptures have been reported with the wide-awake surgical approach by Lalonde and colleagues\textsuperscript{33} or with a 6-strand core suture–only repair by Elliot and Giesen.\textsuperscript{32}

**SUMMARY OF CHANGES AND CURRENT PRACTICE**

A striking finding in the global review of practice is the variations in methods used in individual units and by different surgeons. Nevertheless, the commonalities are clear and straightforward. The review suggests that treatment guidelines, rather than details of techniques, are essentially identical in current practice. Surgeons and therapists adopt methods that they are comfortable with and find reasonable, but there are common underlying principles:

1. Primary or delayed repairs continue to be a standard practice in digital flexor tendon repair. Direct end-to-end repair using multi-strand core suture (4-strand, 6-strand, or 8-strand repair) has been increasingly used in the last 10 years.
2. Although current repair methods vary, some principles are universal, such as using strong core sutures, ensuring knot security, using secure suture-tendon junctions, creating tighter tension over the repair site,\textsuperscript{34} and ensuring sufficient core suture purchase (1.0 cm).\textsuperscript{35,36}
3. 3-0 or 4-0 sutures are used for making core sutures, and 6-0 sutures are used for peripheral sutures.\textsuperscript{36} The importance of adding peripheral sutures to prevent gapping of the repair site is stressed by many surgeons and is supported by in vivo and ex vivo biomechanical studies.\textsuperscript{8,9,13,14} In contrast,
Table 1
The methods used currently in some hand surgery units in direct end-to-end flexor tendon repairs

<table>
<thead>
<tr>
<th>Units</th>
<th>Core Sutures</th>
<th>Peripheral Sutures</th>
<th>Postoperative Motion</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayo Clinic</td>
<td>Modified Pennington, double Tsuge, double Kessler</td>
<td>Simple running or simple locking</td>
<td>Synergistic hand motion Place and hold, active motion, week 3 onward</td>
<td>United States</td>
</tr>
<tr>
<td>Washington University, St Louis (MO)</td>
<td>8-strand looped suture repair (ie, Gelberman-Winters)</td>
<td>Simple running</td>
<td>Synergistic hand motion Passive motion Active motion, week 3 onward</td>
<td>United States</td>
</tr>
<tr>
<td>Hospital for Special Surgery, New York (NY)</td>
<td>Cruciate</td>
<td>Interlocking or running locking</td>
<td>Place and hold Wrist tenodesis with active extension/flexion</td>
<td>United States</td>
</tr>
<tr>
<td>Stanford University, Palo Alto (CA)</td>
<td>Modified Kessler plus 2-strand horizontal mattress suture</td>
<td>Simple running</td>
<td>Place and hold Active motion, week 4 onward</td>
<td>United States</td>
</tr>
<tr>
<td>Saint John Regional Hospital</td>
<td>Double Kessler</td>
<td>Simple running</td>
<td>Midrange active protocol Abandon place and hold</td>
<td>Canada</td>
</tr>
<tr>
<td>University of Bern</td>
<td>6-strand Lim/Tsai</td>
<td>Simple running</td>
<td>Green/yellow/red protocols chosen by severity of injuries/quality of surgery22</td>
<td>Switzerland</td>
</tr>
<tr>
<td>Verona University</td>
<td>4-strand Kessler</td>
<td>Simple running</td>
<td>Active-motion protocol</td>
<td>Italy</td>
</tr>
<tr>
<td>Broomfield Hospital, Chelmsford</td>
<td>4-strand Evans/Smith 6-strand Tang</td>
<td>Simple running None</td>
<td>Midrange active protocol</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>Chang Gung Memorial Hospital</td>
<td>4-strand, mostly 6-strand, occasionally</td>
<td>Simple running</td>
<td>Passive motion, 2 wk Active motion, week 3 onward</td>
<td>China</td>
</tr>
<tr>
<td>Nantong University</td>
<td>6-strand M-Tang, 4-strand U-shaped, cruciate</td>
<td>Interrupted or simple running</td>
<td>Midrange active protocol</td>
<td>China</td>
</tr>
</tbody>
</table>

A recent case series shows that a strong core suture (6 strands or greater), made with appropriate tension over the repair site, may avoid the need for peripheral sutures.32

4. Recent laboratory findings have been translated into clinical practice, including trimming of the partially lacerated tendon ends to reduce tendon gliding resistance, excision of 1 slip of the FDS, starting the postoperative motion a few days after surgery (rather than the next day),15,34 ensuring that tendon movement relies on smooth tendon gliding rather than greater force during rehabilitation, and avoiding extreme active flexion during early active tendon motion.26

5. In the past 10 years, theories about treatment of the pulleys have changed.26,37 A part of the A2 pulley can be incised to free tendon motion, and the entire A4 pulley may be incised to allow repair and tendon movement if other pulleys and the major part of the sheath are intact. Complete closure of the sheath is not considered necessary by most surgeons.
6. Combined active-motion/passive-motion regimes are the mainstay of postoperative care, but details of exercise protocols vary. Midrange active motion has emerged and has begun to be incorporated into active-motion regimes.

7. Synergistic wrist flexion and extension while the repaired finger is actively moved is now often incorporated to a motion regime. Rubber-band traction has mostly been abandoned.

8. Tendon repair methods in more severe hand trauma, such as replantation, are mostly the same as those used for a simple tendon laceration, but the FDS is not usually repaired.

9. New repair devices such as Teno Fix, and suture materials like barbed sutures, have not been adopted widely and are not currently used in the units reviewed in this article.

10. Distal tendon junctions can be achieved without a pull-out suture. The pull-out suture is no longer used and has been replaced by new methods in some units.

**TECHNIQUES KEY TO SUCCESS**

The aim of flexor tendon repair is near-complete restoration of range of active digital flexion, while avoiding rupture of the repair and formation of serious adhesions or joint contracture. Surgeons also aim to achieve predictable results. Following key guidelines is important in reaching these goals:

1. **The surgical repair needs to be strong enough.** Though there are a variety of methods to make a strong surgical repair, and it does not seem to matter which one surgeons choose. Strength can be achieved through a multistrand repair, large-caliber suture, or special devices that hold tendon ends tightly and strongly. The strength of the repair is essential, because the biological tendon healing strength does not increase for 2 to 3 weeks after surgery, and the risk of rupture is greatest during the first 2 weeks, when only the baseline surgical repair strength is holding the tendon ends together.

2. **Avoiding gapping.** Intraoperative validation of a tight, gap-free repair is important. A certain tension across the repair site is helpful to resist gapping. This tension can be achieved by using an efficient peripheral suture, a tighter core suture, or both.

3. **Intraoperative testing of the repair site.** Intraoperative testing of the repair site for possible gapping is important after completion of the repair. This testing can be achieved by passively extending the finger, or asking the patient to move actively during wide-awake surgery.

4. **Proper treatment of the major pulleys allows free gliding of the tendon.** Major annular pulleys are the narrow parts along the tendon gliding path. Venting of the narrow portions frees tendon gliding and avoids catching the repair site against the pulleys; however, overventing causes tendon bowstringing. Preservation of the entire A2 pulley can be harmful in some situations, such as when there are edematous tendon ends. Venting a part of the pulleys should only be done when other annular pulleys are intact. Surgeons should understand the intricate balance among the vented and preserved portions of the annular pulleys, and, of particular note, the entire A2 pulley should not be vented.

5. **Active tendon movement with lower tension over the repair site.** Both synergistic wrist motion and midrange active motion aim to reduce tension at the repair sites during active digital motion. Tension placed on tendons during active motion varies greatly with hand position and finger flexion ranges. Avoiding possible disruption of the repair by high-tensile load is a key to successful rehabilitation. Regimes can be designed to incorporate synergistic hand motion and midrange-only motion to reduce the tension, increasing the safety of tendon motion therapy.

It is now commonly understood that the following should be avoided: a weak repair, a loose repair (no tension across repair site), a repair with a short core suture purchase, repair gapping during intraoperative test with active tendon motion, constriction of the repair site under a tight A2 or A4 pulley, massive sutures that make the tendon surface rough, and a tendon that is bulky and is difficult to move after repair. Although any of these signals a poor repair, 2 or 3 such problems indicates that the repair is bound to disrupt or become stuck in serious adhesions, and heralds failure of the surgery.

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