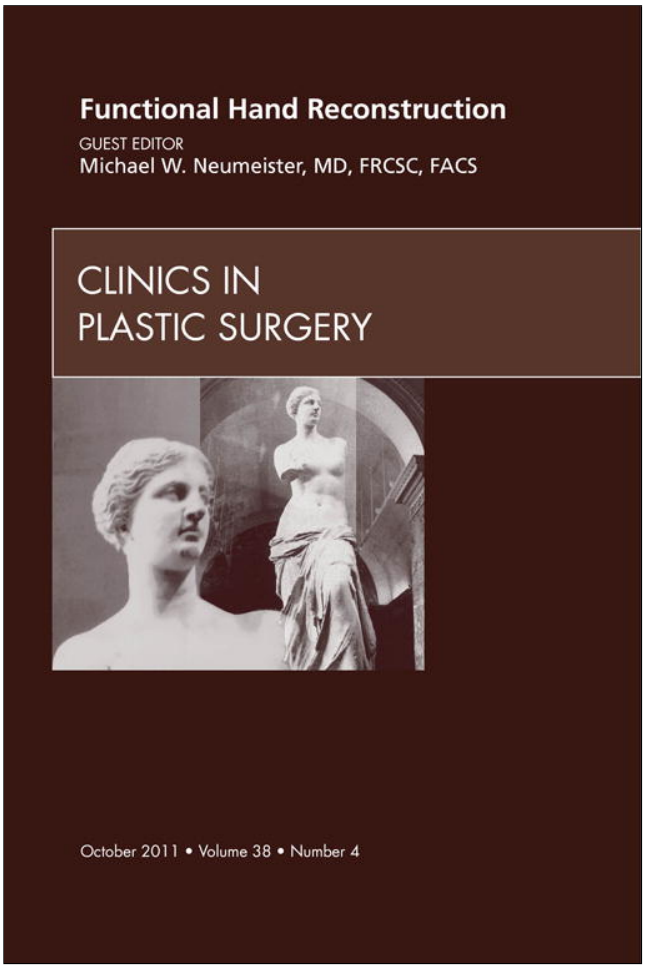

Reconstruction of the Hand with Wide Awake Surgery

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KEYWORDS

• Wide awake hand surgery • Epinephrine finger
• Tourniquet-free hand surgery • Sedation-free hand surgery
• Hole-in-one local anesthesia • Wide awake tendon repair

HOW DO MOST PATIENTS REACT TO BEING AWAKE DURING THE SURGERY?

Most people prefer wide awake hand surgery to having work done on their teeth. The pain is similar if not less with the hand surgery, there is no one working in their mouth, and they do not have to look or listen if they do not want to. Those who want nothing to do with the surgery can look away, listen to music with earphones, or watch movies. As there is no tourniquet used, the patients are totally comfortable. Many patients, if not the majority, are interested in seeing what is happening, and those who are interested are allowed to wear a mask and observe.

Surgeons who have never used the technique often remark, "My patients need sedation." Although some patients are better off asleep or sedated, most prefer the wide awake alternative if it is offered to them in a positive light and if they understand it. After all, most dental procedures are now performed using the wide awake approach, and that is with the surgeon working inside their mouth in which there are airway and communication issues that are not present in hand surgery. Despite these problems, most patients do not want sedation or general anesthesia to have a tooth filled. Patients who have had a wide awake carpal tunnel release feel the same way about their hand surgery.

If patients really need sedation or general anesthesia, it is provided to them. This is in the minority of hand surgery patients, as it is in dental surgery.

WHY DO MOST PATIENTS PREFER WIDE AWAKE HAND SURGERY ONCE THEY HAVE BEEN EXPOSED TO IT?

Most patients prefer wide awake hand surgery for the same reasons they prefer being wide awake when they have a tooth filled. It reduces surgeries like carpal tunnel, trigger finger, operative reduction of fractures, and tendon repairs to the simplicity of going to the dentist. After the surgery, they simply sit up, elevate their totally comfortable hand, and walk out to go home. They never get nausea or vomiting. They get no urinary retention or sedation-induced dizziness. They do not need to get anyone to stay with them or look after them or their children the night of the surgery. They do not have to be admitted to hospital overnight.

They have only 1 visit to the hospital because they do not need to have a second preoperative testing visit. This means that they only need to leave work or get a babysitter one time, the day of the surgery.

They do not need to endure or pay for blood tests, electrocardiography, chest radiography, preoperative medical consultations, anesthesiology fees, or postoperative admissions for the interaction of their medical problems with sedation or general anesthesia.

Many patients do not like to leave control of their faculties to sedation or general anesthesia they do not need to have.

They get to speak to their surgeon during the surgery. The surgeon can answer their questions

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and educate them on good postoperative care and activity as well as return-to-work instructions. They can establish a verbal relationship with the surgeon outside the preoperative consultation.

WHY DO SURGEONS WHO HAVE USED THIS APPROACH LIKE IT?

The surgeons no longer have to wait for an anesthesiologist to do a hand surgery case. The surgery no longer has to be done in the main operating room because all the monitoring required for sedation or general anesthesia is not required. The only 2 medications that are given to the patient are lidocaine and epinephrine, which have now been given to millions of patients in dental offices without monitoring with ultimate safety for more than 60 years. Hand surgery in the office or clinic is more efficient and convenient for the surgeon. Efficiency is increased because of minimal turnover time. Surgeons no longer have to admit and look after patients who underwent hand surgery with medical problems aggravated by sedation or general anesthesia postoperatively.

The initial impetus for the widespread use of wide awake hand surgery in Canada was the difficulty surgeons had in getting hand surgery into the main operating room with an anesthesiologist. The approach is now preferred in many surgeries because watching patients actively move reconstructed parts during the surgery has improved outcomes.[1]

EPINEPHRINE IN THE FINGER FOR HEMOSTASIS DELETES THE TOURNIQUET REQUIREMENT

There was a myth that epinephrine should never be injected into the fingers, nose, ears, and toes. It was based on the theoretical risk that epinephrine caused infarction in body parts with end arteries. The myth originated between 1920 and 1945 and was cemented with the writing of the first American textbook on hand surgery by Stirling Bunnell in 1945. This myth has been clearly shown to be not valid by the following 4 seminal papers and several others.[2–9]

The first of the 4 papers was published in 2007 and traces the root of the epinephrine myth to its true source, procaine.[10] There are 48 cases of finger infarction with local anesthetics in the world literature; almost all of them were before 1950. Twenty-one of those were with epinephrine mixed almost exclusively with procaine. Twenty-seven of those were with procaine without epinephrine. More fingers died with procaine *without* epinephrine than with procaine *with* epinephrine. Procaine was the first synthetic local anesthetic and replaced injected cocaine in 1903. It was the new caine, hence the term Novocaine. It was the only widely used local anesthetic agent until lidocaine became available in 1948. Procaine was quite acidic with a maximum stability pH of 3.6, less than the physiologic pH of 7.4. It became more acidic as it sat on the shelf.[11] Yellowish procaine that had been on the shelf for some time was injected into patients in the 1940s,[12] as the first law requiring expiration dates was passed in 1979 by the US Food and Drug Administration (FDA).[13] In 1948, the US FDA issued a warning about toxic batches of acidic procaine (Novocaine) that had induced tissue necrosis. One batch had a pH as low as 1, which is extremely acidic.[14] Clearly, aged acidic procaine was responsible for tissue death before 1950 and likely was the cause of the death of the fingers attributed to epinephrine. There is not 1 case of finger death caused by lidocaine with epinephrine in the world literature.[15]

The second paper that ended the epinephrine myth was written in 2003.[16] This paper showed that epinephrine-induced vasoconstriction could be reliably reversed in the human finger with the injection of the α-antagonist phentolamine (available since 1957[17]). This study was performed by the Dalhousie University alumni plastic hand surgeon volunteers. If 1 mg of phentolamine in 1 cc of saline is injected wherever epinephrine is injected, the vasoconstrictive effect of 1:100,000 epinephrine is reliably reversed in the human finger in an average of 85 minutes.

The third paper was a 2-year prospective consecutive clinical series of 3110 surgeries in the fingers and hand with elective epinephrine injection published in 2005.[18] In this 6-city, 9-surgeon study, there were no cases of digital infarction and phentolamine rescue was never required.

The fourth paper was a review of all 59 cases of accidental high-dose (1:1000) epinephrine injection in the finger in the world literature.[19] There was not 1 case of finger death even though only 13 patients were treated with phentolamine. If 1:1000 epinephrine has yet to be reported to kill a finger, it is unlikely that 1:100,000 ever will, especially with the availability of the phentolamine antidote.

Epinephrine in the fingers and hand deletes the need for tourniquet, which deletes the need for sedation, Bier block, brachial plexus block, or general anesthesia. Patients with sedation, general anesthesia, or motor nerve block are mostly unable to cooperatively, comfortably, and reliably move the reconstructed hand and finger structures during the surgery in most cases.

CONTRAINDICATIONS TO EPINEPHRINE IN THE FINGER

If a fingertip is nice and pink before a surgery, it will be nice and pink after the surgery unless the surgeon damages the blood supply to the skin during the surgery. However, if a finger is dusky or blue before the surgery, it may be wise not to use epinephrine.

A surgeon probably should not inject epinephrine in the finger if he does not know about phentolamine, the antidote to epinephrine-induced vasoconstriction. This would be similar to a surgeon who injects morphine when he does not know about naloxone. All that the surgeon needs to know about phentolamine is that 1 mg of the antidote in 1 cc of saline will reliably reverse epinephrine-induced vasoconstriction, as described previously.

HOW TO INJECT LIDOCAINE AND EPINEPHRINE FOR THE HAND AND FINGER SURGERY

The tumescent concept is used. The goal is to get the lidocaine and epinephrine molecules wherever there is likely to be any incision or dissection. Injection of low concentration with large volume is preferred to high concentration of anesthetic agents in nerve blocks. To stay less than 7 mg/kg of lidocaine with epinephrine, the dosage shown in **Table 1** is used.

The local anesthesia can be injected rapidly (painfully) with a 25-gauge needle, as the author did in the first 22 years of his practice, or slowly with a 27-gauge needle and bicarbonate to provide an almost pain-free experience as described in the hole-in-one local anesthetic technique, which means that all that the patient feels for pain is the first poke of the first injection.[20,21] The last 2 references clearly explain with text and film how to inject a local anesthetic in an almost pain-free fashion.

A large volume is injected in the most proximal location that any dissection is likely to take place to block the nerves distally. For example, for a zone 1 flexor tendon repair in the hand in which the dissection may reach into the palm, 10 cc would be injected at the most proximal of likely incisions as shown in **Fig. 1** to block the distal nerves (see **Fig. 1**). After waiting 15 to 30 minutes to allow for distal anesthesia to set in, the distal parts of the palm and finger are injected for the epinephrine-induced vasoconstriction effect in a pain-free fashion as described in **Fig. 2**. The same technique would be used for the Dupuytren palmar fasciectomy.

The technique of injection for carpal tunnel surgery has been recently described in detail in text and film.[21] **Figs. 3** and **4** summarize the technique; 10 cc is injected between the median and ulnar nerves, and then 7 to 10 cc is injected under the skin down into the palm to tumesce at least 5 mm of skin on either side of the incision.

For tendon transfer such as extensor indicis to extensor pollicis longus, normally 30 to 40 cc of local anesthesia is now injected in the area shown in **Fig. 5**. For trapeziectomy, the radial side of the hand is injected volarly and dorsally as well as in the joint with a total of 40 cc of local anesthesia as in **Fig. 6**. For spaghetti wrist, 100 to 150 cc of 1/4% lidocaine with 1:400,000 epinephrine is

Table 1
Dosage and concentration of lidocaine with epinephrine tumescent fluid to be injected in the forearm, hand, and finger

Volume Required to Tumesce the Area of Dissection	Concentration of Lidocaine and Epinephrine
Less than 50 cc	1% lidocaine with 1:100,000 epinephrine
Between 50 and 100 cc	1/2% lidocaine with 1:200,000 epinephrine
Between 100 and 200 cc	1/4% lidocaine with 1:400,000 epinephrine

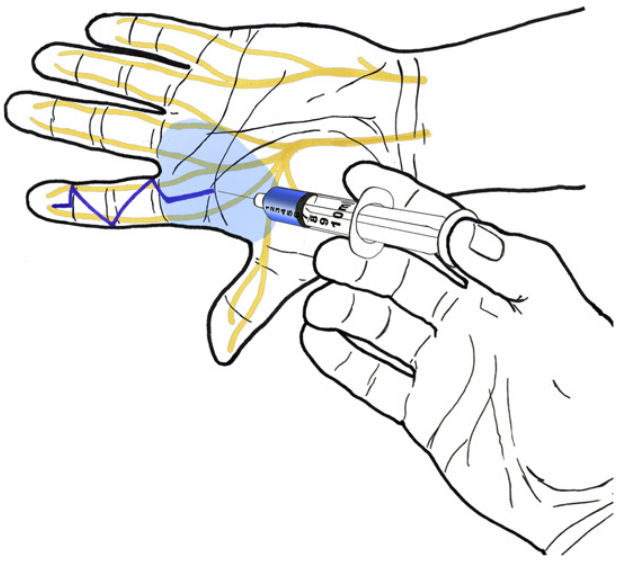

Fig. 1. For flexor tendon repair or the Dupuytren palmar fasciectomy, 10 cc of 1% lidocaine with 1:100,000 epinephrine plus 1 cc of 8.4% bicarbonate is injected into the hand in the most proximal part of the likely dissection to block the distal nerves. (*Reproduced from* Lalonde DH. Wide-awake flexor tendon repair. Plast Reconstr Surg 2009;123(2):623; with permission.)

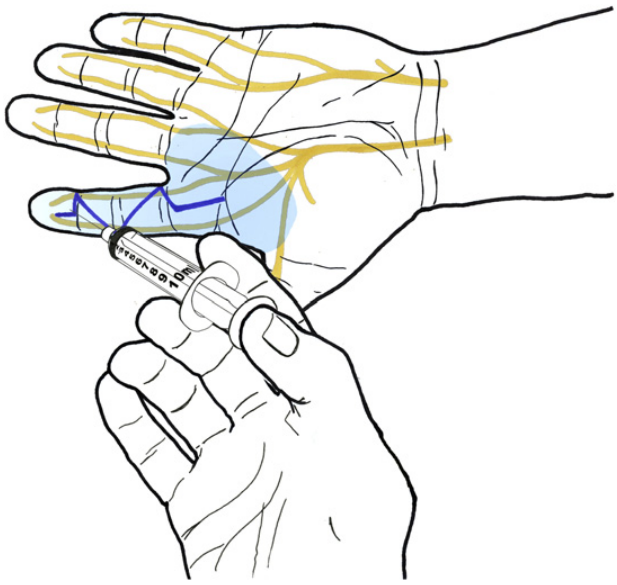

Fig. 2. Secondary injections in flexor tendon repair or the Dupuytren palmar fasciectomy. Another 4 cc is injected between the first injection and the proximal phalanx, 2 cc into the center of each of the proximal and distal phalanges, and 1 cc into the middle of the distal phalanx. (*Reproduced from* Lalonde DH. Wide-awake flexor tendon repair. Plast Reconstr Surg 2009;123(2):623; with permission.)

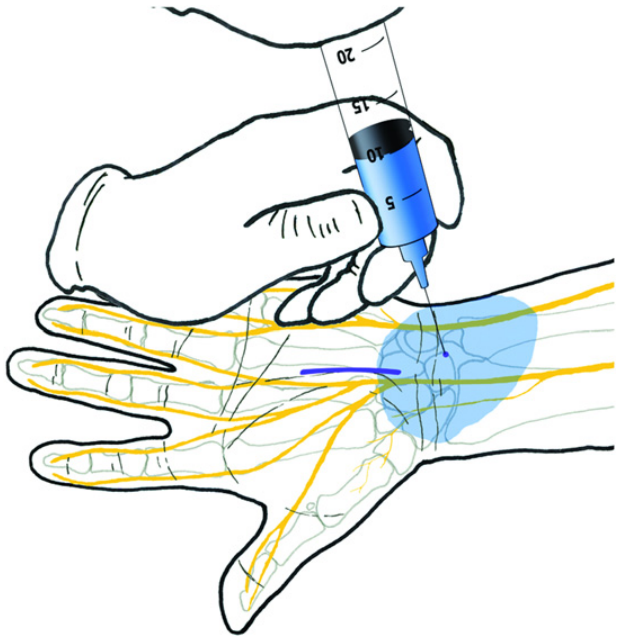

Fig. 3. For carpal tunnel surgery, 10 cc of 1% lidocaine with 1:100,000 epinephrine plus 1 cc of 8.4% bicarbonate is injected very slowly under the skin and under the forearm fascia to bathe the space between the median and ulnar nerves. The needle is moved very little as shown in the film in Lalonde (2010).[21] The tumescent effect of a slowly injected large volume and a nonmoving needle permits the patient to feel the pain of only the first poke of the 27-gauge needle going into the skin (hole in one). (*Reproduced from* Lalonde DH. "Hole-in-one" local anesthesia for wide-awake carpal tunnel surgery. Plast Reconstr Surg 2010;126(5):1642–4; with permission.)

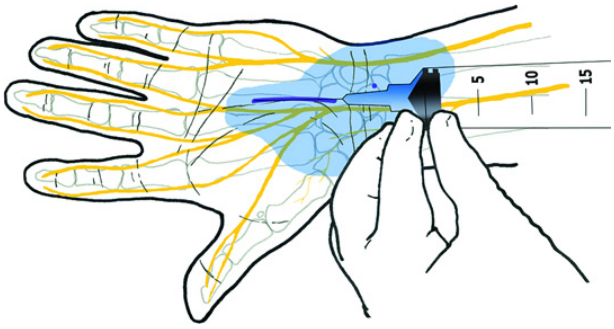

Fig. 4. The final 7 to 10 cc is injected underneath the incision by advancing the needle very slowly without jerking forward and never letting the needle get ahead of 3 to 4 mm of firm, white, tumescent subcutaneous tissue so that the needle never contacts unanesthetized nerves. The goal is to get at least 4 to 5 mm of firm, white, tumescent subcutaneous tissue on either side of the incision. (*Reproduced from* Lalonde DH. "Hole-in-one" local anesthesia for wide-awake carpal tunnel surgery. Plast Reconstr Surg 2010;126(5):1642–4; with permission.)

injected wherever dissection and incisions will take place as shown in **Fig. 7**. For ulnar nerve decompression or transposition at the elbow, 60 cc of 1/2% lidocaine with 1:200,000 is injected wherever incisions and dissection are to be performed (**Fig. 8**), beginning proximally and working distally as in all surgeries.

WIDE AWAKE FLEXOR TENDON REPAIR

The wide awake approach has 4 major advantages to conventional tourniquet methods.

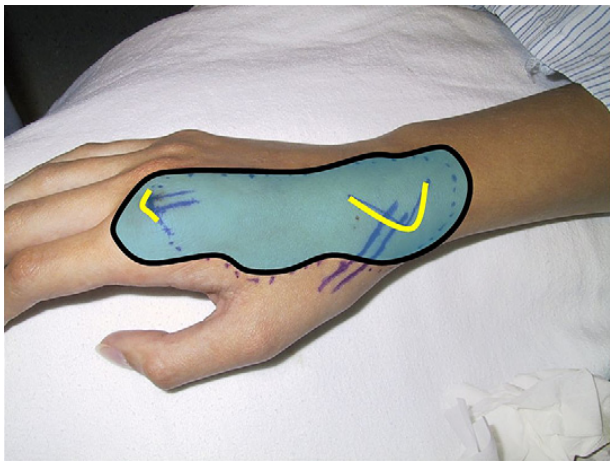

Fig. 5. Extensor indicis proprius to extensor pollicis longus tendon transfer. The blue area is injected with 20 mL of 1% lidocaine with 1:100,000 epinephrine 30 minutes before the operative procedure. Yellow lines indicate incisions. (*Reproduced from* Bezuhly M, Sparkes GL, Higgins A, et al. Immediate thumb extension following extensor indicis proprius to extensor pollicis longus tendon transfer using the wide awake approach. Plast Reconstr Surg 2007; 119(5):1507; with permission.)

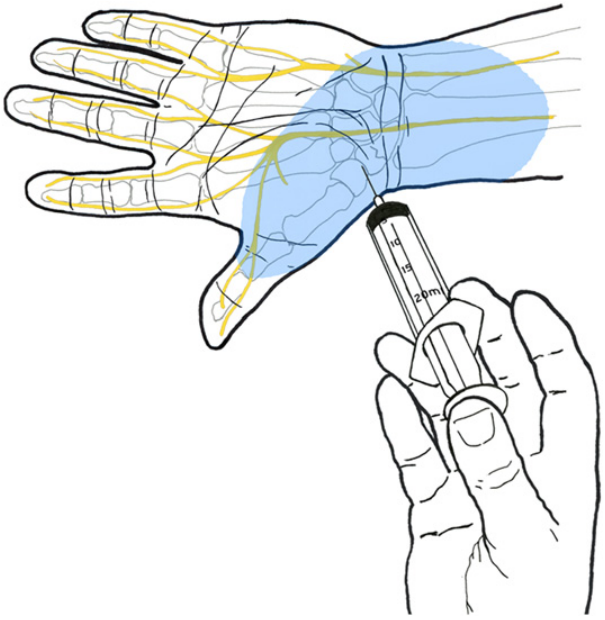

Fig. 6. For trapeziectomy, a total of 40 cc is injected volarly and dorsally as well as in the joint to totally anesthetize the radial side of the hand. (*Reproduced from* video 4 in Mustoe TA, Buck II DW, Lalonde DH. The safe management of anesthesia, sedation and pain in plastic surgery. Plast Reconstr Surg 2010; 126(4):165–76e; with permission.)

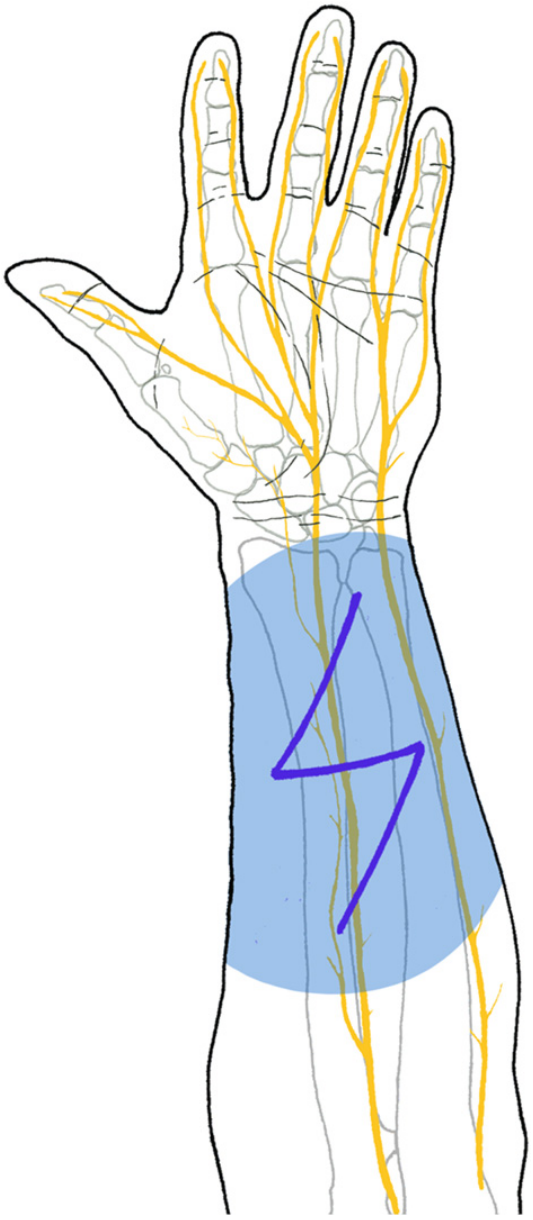

Fig. 7. For spaghetti wrist, 100 to 150 cc of 1/4% lidocaine with 1:400,000 epinephrine is injected wherever dissection and incisions will take place. (*From* Lalonde DH, Kozin S. Tendon disorders of the hand. Plast Reconstr Surg 2011;128(1):1e–14e; with permission.)

1. Intraoperative testing of the flexor repair by the pain-free cooperative unsedated patient ensures that there is no gapping of the flexor repair. After each core suture is inserted and tied, the wide awake patient is asked to flex and extend the finger through a full range of motion. Occasionally, the tendon will be seen to bunch up in the suture with active movement because the suture was not pulled tightly enough and a gap in the repair is identified (**Fig. 9**). Tendon gap is the most common cause of flexor tendon repair rupture. Any gaps revealed in the repair with active movement testing can be repaired before the skin is closed. This intraoperative testing has been documented to result in very low rupture rates in patients with compliants.[1] After seeing no gap with active movement intraoperatively, the surgeon can be confident that postoperative gapping will not likely occur unless accidental excessive forces are applied to the repair and he can be more comfortable about initiating early active movement as opposed to passive movement of flexor tendons such as in the Kleinert or Duran regimes. Bier or axillary blocks paralyze forearm muscles, and the patient cannot actively flex finger tendons during surgery.
2. Intraoperative active movement lets the surgeon see that the repair fits through the pulleys. If it does not, additional sutures, repair trimming, or pulley division is performed so that there is a full range of movement before the skin is closed. This helps to avoid postoperative tenolysis.
3. Sheath and pulley destructions are minimized, and good 1-cm bites of tendon are permitted because flexor tendons can be repaired through small transverse sheathotomy incisions through which the sutures for intra-sheath/intra-pulley tendon suturing are inserted (**Fig. 10**).
4. The surgeon gets more than a full hour to talk to the patient during the surgery and gets a feeling

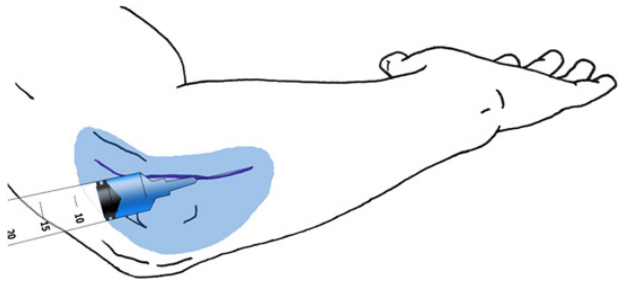

Fig. 8. For ulnar nerve decompression or transposition at the elbow, 60 cc of 1/2% lidocaine with 1:200,000 is injected wherever incisions and dissection are to be performed, beginning proximally and working distally as in all surgeries. (*Reproduced from* video 4 in Mustoe TA, Buck II DW, Lalonde DH. The safe management of anesthesia, sedation and pain in plastic surgery. Plast Reconstr Surg 2010;126(4):165–76e; with permission.)

for the likelihood of postoperative compliance. In addition, intraoperative patient teaching by the surgeon allows the patient to practice the postoperative movement regime in a pain-free comfortable environment. In the author's hospital, this is performed by the hand therapist who participates in patient teaching during the surgery. The sedated patient may not be cooperative and often remembers very little about intraoperative teaching.

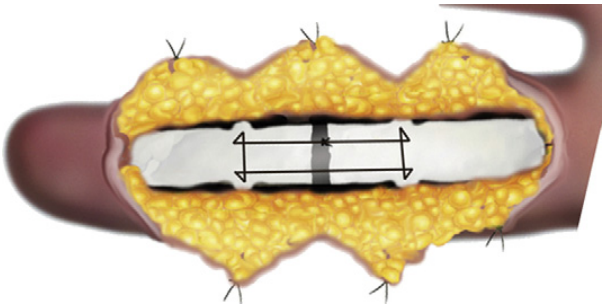

Fig. 9. This tendon has also just been repaired with a core suture that is too loose. This too loosely repaired tendon has been tested with intraoperative full range of active movement of the freshly repaired flexor tendon during wide awake flexor tendon repair. Tendon bunching in the suture has occurred, and a gap has revealed itself. The gap can now be corrected before the skin is closed, and repeated active movement testing will verify that the suture is snug enough to withstand the forces of active flexion. It is better to discover that a core suture is too loose during the surgery when it can be redone than after the surgery when a postoperative rupture occurs. (*Reproduced from* Higgins A, Lalonde DH, Bell M, et al. Avoiding flexor tendon repair rupture with intraoperative total active movement examination. Plast Reconstr Surg 2010;126(3):941; with permission.)

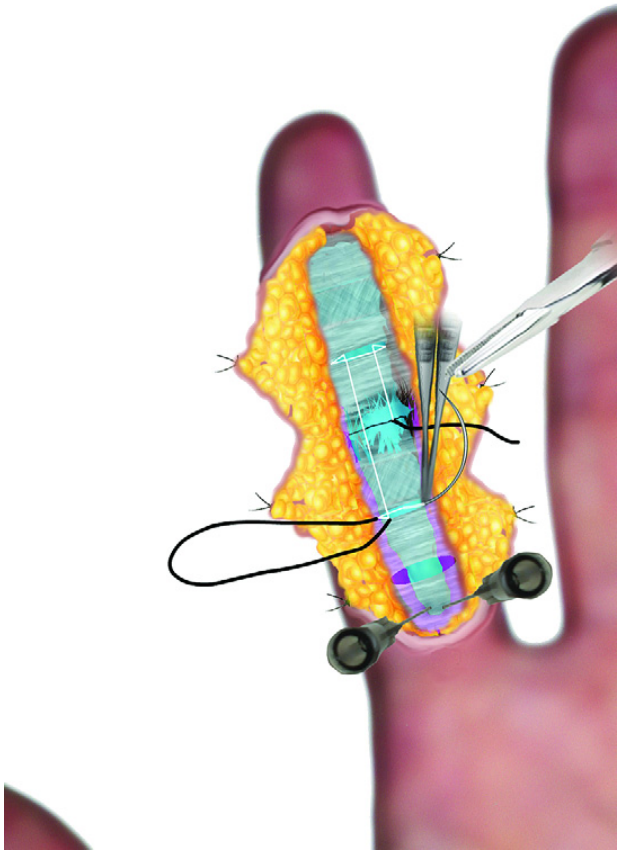

Fig. 10. The needle and thread are passed through proximal and distal sheathotomies to purchase 1 cm of tendon bite without destroying sheath and pulleys. The sheathotomy incisions can be closed with a fine absorbable suture. This type of repair can only be performed in awake patients who can actively test the repair to verify that the suture is only in the tendon and has not been caught inside the sheath. (*From* Lalonde DH, Kozin S. Tendon disorders of the hand. Plast Reconstr Surg 2011;128(1):1e–14e; with permission.)

TENDON TRANSFERS

In tendon transfers such as extensor indicis proprius to extensor pollicis longus or flexor digitorum superficialis to flexor pollicis longus, the tension of the transfer can be tested by the patient with active movement during the surgery to be sure that the transfer is not too loose or too tight.[22] The tension of the transfer can be adjusted by the surgeon to be sure it is just right before the skin is closed.

TENOLYSIS

With tenolysis, the tourniquet-free, comfortable, unsedated, and therefore cooperative patient can use his own muscles to assist the surgeon in performing tenolysis during the surgery by pulling hard on the tendon to rupture adhesions in between bouts of surgical lysis of adhesions by the

surgeon. In addition, these patients get to see their final range of active motion in a totally pain-free state at the end of the surgery so that they know where they will end up if they are faithful to their therapy after surgery. As there is no tourniquet, there is no rush for the surgeon to perform this often difficult surgery.

FINGER FRACTURES

In open or closed operative reduction of finger fractures with Kirschner (K) wires, the patient can comfortably actively move the fingers after fixation under fluoroscopy to see if there is enough stability in the fixation to support early protected movement or if further K wires or other forms of fixation will be necessary before the end of the procedure.

JOINT FUSION

In fusions such as of the thumb metacarpal phalangeal joint, the unsedated patient can help to choose the final angle of the joint during the surgery. The patient and surgeon can watch the thumb actively move in all directions after temporary K-wire fixation of the joint during the surgery to verify if the angles are ideal. Permanent angles can then be fixed as desired before closing the skin.

PROXIMAL INTERPHALANGEAL JOINT ARTHROPLASTY AND FINGER EXTENSOR TENDON SURGERY

In proximal interphalangeal joint arthroplasty and finger extensor tendon surgery, such as sagittal band reconstruction or boutonniere surgery, the surgeon reconstructs the extensor mechanism and then sees that he has placed the sutures in such a way that they will support the active range of motion performed by the patient during the surgery. Sometimes the surgeon sees the sutures let go or restrict movement as they have not been placed in an ideal location. He gets the opportunity to replace the sutures in a more favorable location before closing the skin.

TRAPEZIECTOMY FOR BASAL JOINT ARTHRITIS

In trapeziectomy with or without ligament reconstruction, the surgeon can see the patient actively move the thumb during the surgery to see if the metacarpal base is grinding on anything after the trapeziectomy so that adjustments can be made before the skin is closed, if necessary. Many of these patients are older with medical comorbidities. They just get up and go home like after they have been to the dentist as there has been no sedation.

THE DUPUYTREN CONTRACTURE

This surgery is one of the more difficult ones to perform using the wide awake approach because of the close proximity of the digital vessels to the cords. This may not be the best surgery for a tourniquet hand surgeon to start with. Even though the digital arteries are bathed in epinephrine, they continue to pump and their little branches can produce troublesome bleeding during the surgery. Surgeons who love a totally dry field may be a little troubled by this at the beginning. However, the patient gets to see the whole range of motion obtained with his active pain-free movement during the surgery and understands the goal that he can reach with therapy after the surgery.

With needle aponeurotomy, the patients are wide awake in any case. Some prefer to just anesthetize the skin and leave the digital nerves live so that the surgeon is unlikely to cut the nerves with the needle. Others simply anesthetize the whole area as in other wide awake surgeries so that the patient feels no pain during the surgery, the risk being perhaps a higher incidence of nerve injury.

TRIGGER FINGER OR THE DE QUERVAIN RELEASE

In trigger finger, 4 cc of lidocaine with epinephrine is injected in the fat just below the center of the skin incision as the A1 pulley itself does not seem to be tender and does not need to be injected. The A1 pulley is released just enough to allow full nontriggering active movement during the surgery by the patient. This approach is particularly helpful when the swelling in the tendon has prevented full flexion preoperatively. The patient gets to see his finger fully flex and extend during the surgery and knows what is possible after the surgery.

In the De Quervain release, 10 cc of lidocaine with epinephrine is injected starting proximally and local injection into the tender tendon sheath is included. Active movement during the surgery by the patient helps the surgeon distinguish the 2 different tendons in the canal and aids with identification and deroofing of separate tunnels within the De Quervain canal.

CARPAL TUNNEL RELEASE

In Canada, more than 70% of carpal tunnel surgeries are now being performed with the wide awake approach.[23] Many of these surgeries have moved outside the main operating room to minor

procedure rooms, in which twice as many procedures can be performed in the same time at one-quarter the cost.[23] In the hospitals in Canada, 3 carpal tunnel procedures are regularly performed per hour with just the surgeon and a nurse assistant who also circulates and turns the room over in a minor procedure room. The surgeon gets a full uninterrupted 15 minutes to speak with the totally sober patient to answer questions and discuss postoperative management, how to avoid problems, and return-to-work issues. Patients appreciate this opportunity. The technique of injection and other details of wide awake carpal tunnel release have been described in detail in text and film.[21]

ULNAR NERVE DECOMPRESSION AT THE ELBOW

After decompression or transposition, the patient can take the elbow through an active range of motion so that the surgeon can see that the nerve does not subluxate. The nerve can be supported with sutures, or the operative plan can be changed if subluxation is seen. In addition, patient positioning is unencumbered by the tourniquet or anesthesia apparatus. Now, this surgery is usually performed with the shoulder flexed and the elbow lying comfortably at the level of the patient's face. The hand can be behind the patient's head if this is comfortable for the patient's shoulder. Many patients do have shoulder position discomfort problems, and these problems can easily be accommodated for in the wide awake patient.

COMPLEX SURGERIES SUCH AS TENDON GRAFTING, SECONDARY SURGERY

The opportunity to watch the comfortable unsedated patient move the structures being analyzed adds a new dimension to the surgery. This helps greatly in complex surgeries in which the surgeon is not sure what he will find to reconstruct. An example is a complex maneuver such as tendon grafting. In secondary surgery, this approach has often resulted in changes in intraoperative strategy for the patients for the better. The more complicated the case, the better the patient be wide awake.

CAUTERY, LET DOWN BLEEDING AND HEMATOMA

Cautery is rarely used any more for hand surgery. The skin always bleeds during the initial incisions. However, the field gets the time to dry up and clot before the skin is closed in any lengthy surgery. Larger veins can be tied or clipped. Hematoma has not been a problem despite no cautery for the past 15 years in brief procedures such as trigger finger and carpal tunnel release.

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