

A Cadaveric Study for the Improvement of Thread Carpal Tunnel Release

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Purpose The thread carpal tunnel release (TCTR) technique has been improved and offers more precise control in dissecting thread placement. The purpose of this cadaveric study was to test the procedure operationally and verify the modified TCTR anatomically.

Methods Eleven unembalmed cadaver wrists underwent the transverse carpal ligament (TCL) release by using the modified TCTR technique. An experienced observer dissected each specimen and assessed for completeness of release under direct visual assessment. Injury to the superficial palmar aponeurosis (SupPA), the Berrettini and common digital nerve branches were also recorded as a secondary outcome.

Results Eleven out of 11 wrists (100%) underwent the modified TCTR with complete release of the TCL. All 11 wrists were released without damage to any vital neurovascular structure including the Berrettini branch and the common digital nerves. The SupPA remained intact in all 5 wrists performed with the preservation steps.

Conclusions The modified TCTR technique demonstrated complete division of the TCL while protecting the SupPA as well as the Berrettini and common digital nerve branches.

Clinical relevance The modified TCTR has the potential to offer a clinically safe and effective minimally invasive procedure for complete carpal tunnel release. (*J Hand Surg Am.* 2016; ■ (■): ■–■. Copyright © 2016 The Authors. Published by Elsevier Inc. on behalf of the American Society for Surgery of the Hand. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).)

Key words Carpal tunnel release, carpal tunnel syndrome, ultrasound-guided procedure, thread carpal tunnel release, ultraminimally invasive procedure.

A PREVIOUS STUDY ON 34 HANDS OF 20 patients showed that thread carpal tunnel release (TCTR) is safe and effective, using only 2 needle puncture sites, no incision, local anesthesia, and without need for an operating room. Patients can return to work within a few days after the procedure.¹

Although there were no complications in the previous study, surgeons have difficulty in manipulating

the routing needle to exit the skin at the designated spot in the palm because of the difficulty caused by the thick and stiff tissue mass that makes up the distal portion of the transverse carpal ligament (TCL). In addition, there is a risk of injuring the superficial palmar arterial arch (SPA) if the needle exits too distally,^{2,3} and a risk of incomplete transection of the distal TCL if the needle exits too proximally. Other concerns include potential

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Received for publication February 24, 2016; accepted in revised form July 12, 2016.

Sonosite-Fujifilm Corporation, General Electric, and Ridge & Crest Company provided the devices used in this study. J.G. has financial interest in the devices for TCTR. Danqing

Guo and Danzhu Guo have received a research grant from BayCare Clinic, Green Bay, WI.

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0363-5023/16/■ ■ ■-0001
<http://dx.doi.org/10.1016/j.jhssa.2016.07.098>

injury of common digital nerves or the communicating branch between the ulnar nerve and the median nerve, the so-called “Berrettini branch.”^{4,5}

Recently, the authors revised the TCTR technique with 3 major modifications. First, an entry-at-palm (with exit-in-wrist) technique for the routing needles is used instead of the exit-at-palm technique previously used. With this modification, the needle easily exits at the wrist with the help of wrist extension. This modification provides improved accuracy for needle control in the palm, minimizing the chances of damage to important anatomical structures in this area. Second, a fine needle (27 g) is used as an initial needle prior to passing the first routing larger-bore (18 g) needle. This 27-g needle is used to accurately create the path toward proximal and allows for hydrodissection at the entry point. The importance of this modification is that the SPA and other vital structures can be displaced away from the cutting path. Third, the superficial palmar aponeurosis (SupPA) in the palm is excluded from the cutting loop so that it is preserved.

The purpose of this cadaveric study was to assess and validate these modifications to the TCTR technique.

MATERIALS AND METHODS

General

The study was done on 11 available unembalmed cadaveric wrists, 7 in a cadaver laboratory in Baltimore, Maryland, and 4 in a laboratory in Minneapolis, Minnesota. All specimens were free from signs of trauma, without previous wrist surgery, and maintained a normal TCL.

The ultrasound systems used were the M-Turbo Model from Fujifilm Sonosite Company (Bothell, WA) and the Logic S8 R3 system from General Electric (Boston, MA). Other necessary equipment included skin-marking pens; 1.5-inch 27-g needles; 3.5-inch 18-g spinal needles; 0.9% normal saline; and a length of surgical dissecting thread (Loop&Shear, 0.009 inch in diameter; Ridge & Crest Company, Monterey Park, CA).

The distal edge of the division of the TCL was sonographically determined at the “duck’s beak.” The duck’s beak is a sonographic concept introduced by Rojo-Manaute et al⁶ to describe the appearance of the distal edge of the TCL. In a sonographic longitudinal view, the convergence of the distal portion of the TCL and the SupPA is shaped like a duck’s beak (Fig. 1).

The proximal edge of the TCL was determined by selecting a needle exit site at a point 2 cm proximal to the distal wrist crease.

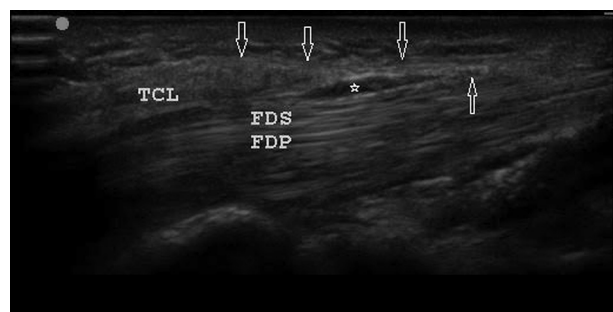


FIGURE 1: Duck’s beak. The TCL blends with the SupPA to show a hyperechoic area shaped like a duck’s beak. The down arrows point to the SupPA that helps form the superficial border of the TCL. The up arrow is at the distal tip of the duck’s beak. The duck’s beak overlies the palmar fat pad, seen as a hypoechoic area (star) between the Duck’s beak and the flexor tendons. FDP, flexor digitorum superficialis tendons; FDS, flexor digitorum profundus tendons.



FIGURE 2: The routing needle travels between the entry and the exit points within the safe zone.

The routing needles travel distal to proximal between the entry point on the palm and the exit point at the wrist and are kept within the “safe zone” between the median nerve and the ulnar artery (Fig. 2). The thread placement routing process is completed in 2 18-g needle passes. The route of the first needle is along the dorsal (deep) surface of the TCL, proximally through the carpal tunnel, and the route of the second pass is on the palmar (superficial) surface of the TCL. The path of the cutting thread is illustrated in Figure 3. The whole routing process is done using real-time visualization via ultrasound and with the simultaneous use of hydrodissection. The details of the routing process are as follows:

First, a 27-g needle is inserted into the skin on the palm of the hand, at a point about 5 mm distal to the SPA, which is visualized using ultrasound. This needle is advanced proximally using hydrodissection with saline, and is passed superficial to the arterial arch. The needle is then directed to penetrate the SupPA and enter the carpal tunnel by penetrating the

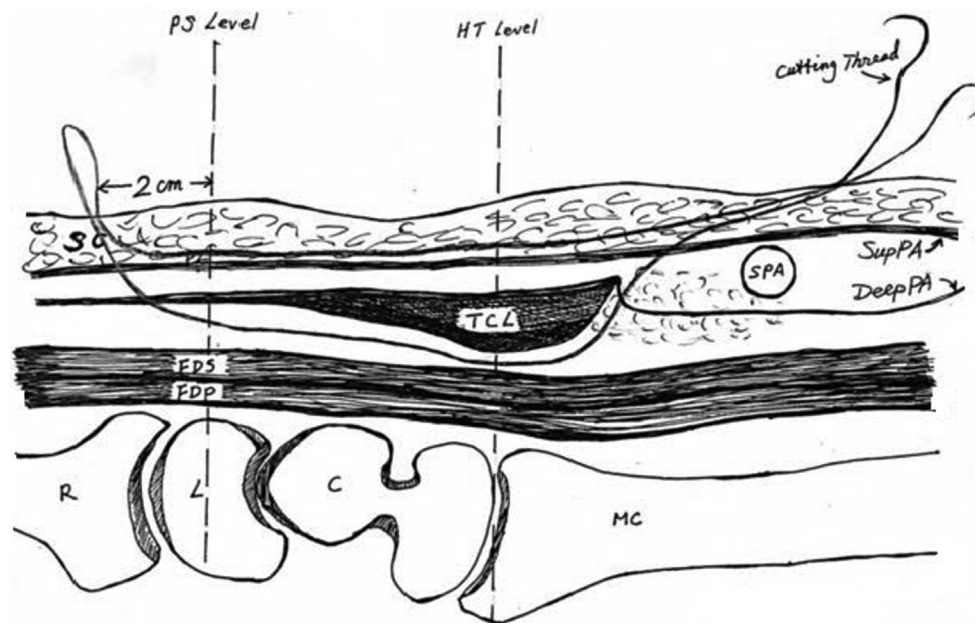


FIGURE 3: The routing path of a cutting thread used in the method with step 3A, without preserving the SupPA. Note that the thread runs superficial to the aponeurosis, thereby including it in the cutting loop. Compare the position of this superficial thread loop with its position shown in Figure 7 that depicts the thread path for the revised method with preserving the SupPA. The method is preferred because it spares the aponeurosis. C, capitate bone; DeepPA, deep palmar aponeurosis; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; HT level, plane of the line connecting the hamate and trapezium bones; L, lunate bone; MC, metacarpal bone; PS level, plane of the line connecting the pisiform and scaphoid bones; R, radius; SC, subcutaneous fibroadipose tissue of the palm.

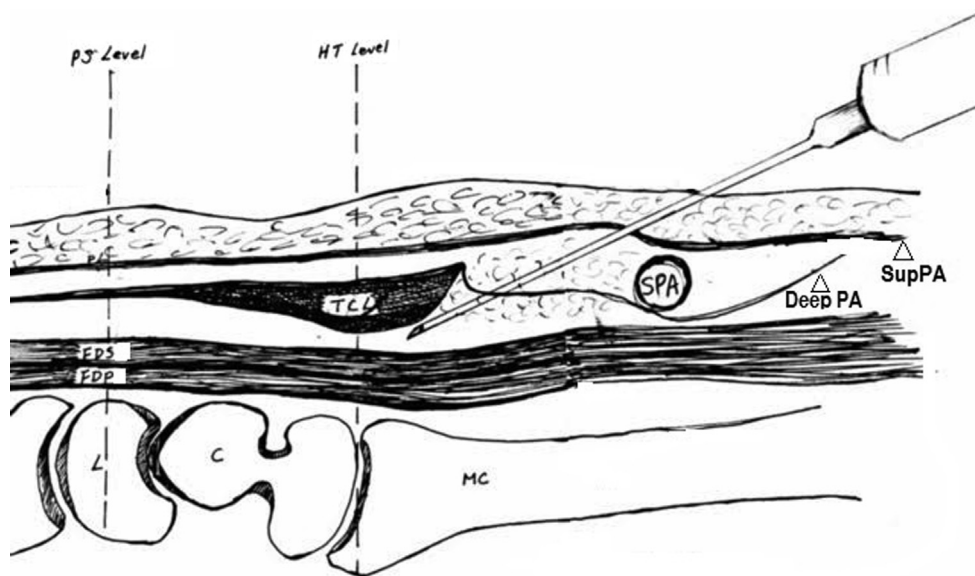


FIGURE 4: Diagram of the path of the starting 27-g needle from entry through the deep TCL surface, into the carpal tunnel. C, capitate bone; DeepPA, deep palmar aponeurosis; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; HT level, plane of the line connecting the hamate and trapezium bones; L, lunate bone; MC, metacarpal bone; PS level, plane of the line connecting the pisiform and scaphoid bones.

deep palmar aponeurosis (Fig. 4). The 27-g needle is then removed.

Next, an 18-g spinal needle is slightly bent at its distal portion with the beveled surface facing the

resulting concavity. It is then inserted at the same skin entry point as was the 27-g needle and advanced into the carpal tunnel along the same path created by the 27-g needle (Fig. 5). It is directed proximally and

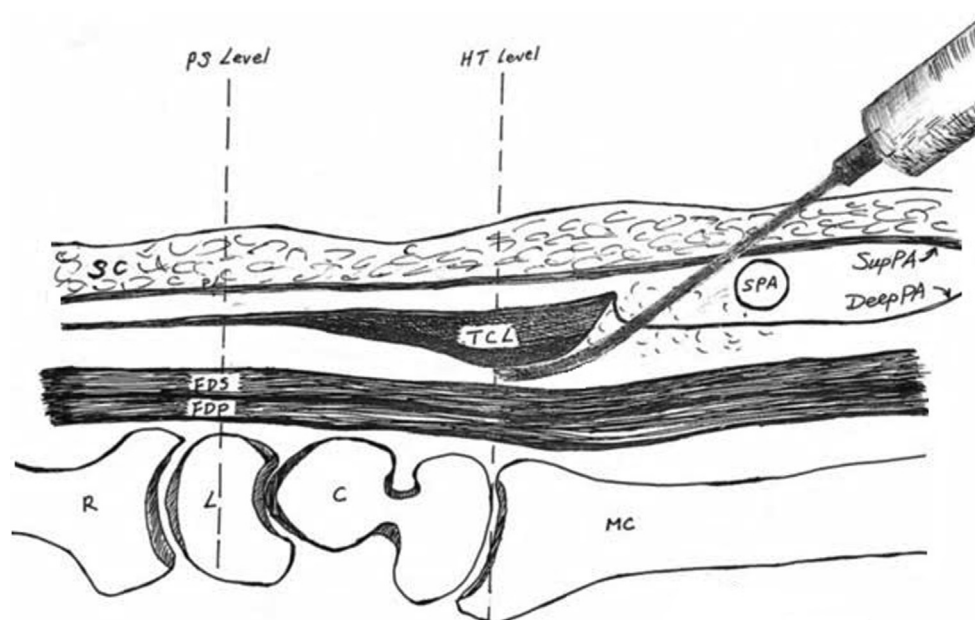


FIGURE 5: First-pass needle with a curved tip, used to place the deep thread. C, capitate bone; DeepPA, deep palmar aponeurosis; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; HT level, plane of the line connecting the hamate and trapezium bones; L, lunate bone; MC, metacarpal bone; PS level, plane of the line connecting the pisiform and scaphoid bones; R, radius; SC, subcutaneous adipose tissue.

advanced inside the carpal tunnel along the dorsal surface of the TCL toward the wrist exit point. With wrist held in extension, the needle is directed superficially when it has traversed the level of the radio-lunate joint and is guided superficially to pass through the exit point. The cutting thread is passed through the needle, and the needle is removed, leaving the thread in the carpal tunnel.

Next, an unbent 18-g spinal needle is inserted at the same palmar skin entry point, advanced subcutaneously along the superficial surface of the SupPA, and directed proximally until the tip emerges through the skin at the same exit point as the first routing needle. The proximal end of the previously placed thread emerging from the wrist at the exit point is then passed back through the needle, proximal to distal, and the needle is removed. This leaves the thread looped around the TCL with both thread ends emerging through the same palmar needle puncture site.

Ultrasound is used to check the entire path of the thread loop in both the longitudinal and the transverse planes to ensure that the loop includes no vital structures (Fig. 6). The TCL is manually transected by a reciprocating back-and-forth motion of the thread until the thread emerges from the skin. Finally, a step designed to exclude the SupPA from the loop, thereby preserving it, was performed in 5 specimens. In the revised technique, the 18-g routing needle in the second pass is guided to penetrate the SupPA at



FIGURE 6: The loop of thread in a longitudinal sonographic view. Arrows indicate the hyperechoic thread encompassing the TCL.

the tip of the duck's beak, before being directed proximally. When this is done, the routing needle in the second pass travels proximally along the dorsal surface of the SupPA, which excludes this structure from the cutting loop (Fig. 7).

In both approaches, the SPA, the Berrettini branch, and the digital nerve branches are protected by excluding them from the thread loop.

RESULTS

Five wrists were done by the procedure with the preservation step and 6 using the standard approach. The accuracy of needle placement at the palm was estimated to be 0.15 to 0.20 mm based on readings from the ultrasound monitor screen using the

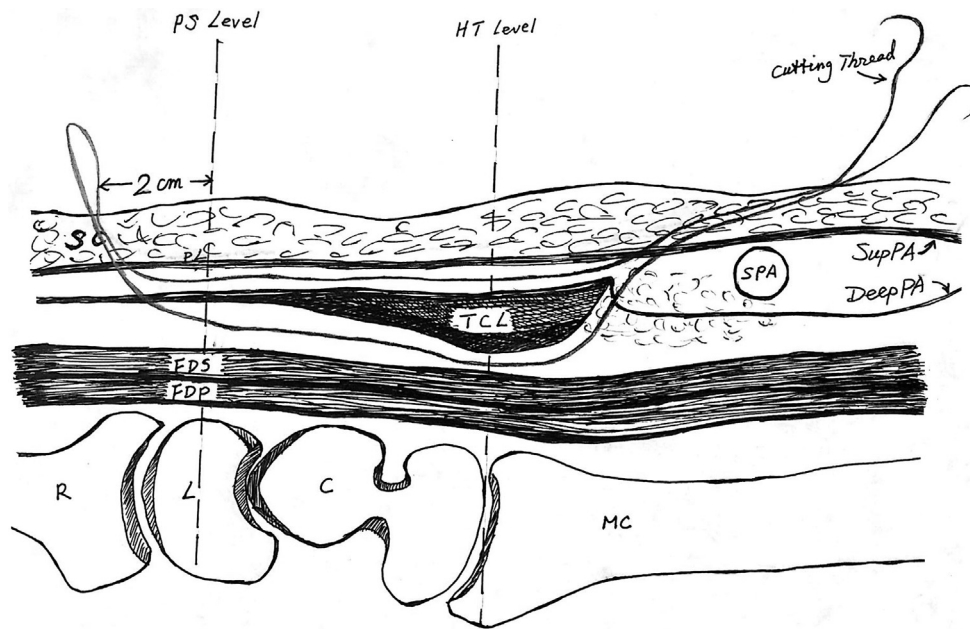


FIGURE 7: The routing path of thread that preserves the SupPA, which is the revised (and preferred) method. Note that in the revised method, the thread is placed deep to the SupPA to exclude it from the cutting loop. Compare this with the thread position in the method shown in Figure 3. C, capitate bone; DeepPA, deep palmar aponeurosis; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; HT level, plane of the line connecting the hamate and trapezium bones; L, lunate bone; MC, metacarpal bone; PS level, plane of the line connecting the pisiform and scaphoid bones; R, radius.

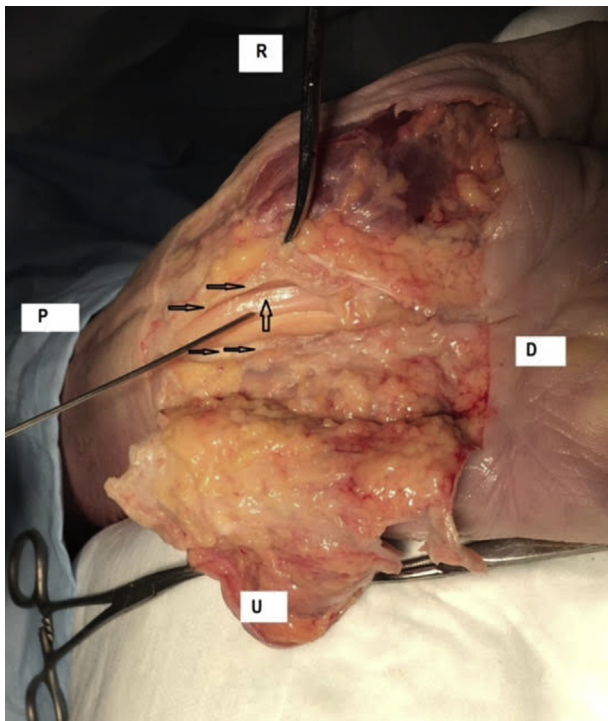


FIGURE 8: Complete TCL division. D, distal; P, proximal; R, radial; U, ulnar; single thick arrow, median nerve; 4 parallel thinner arrows, edges of completely divided TCL.

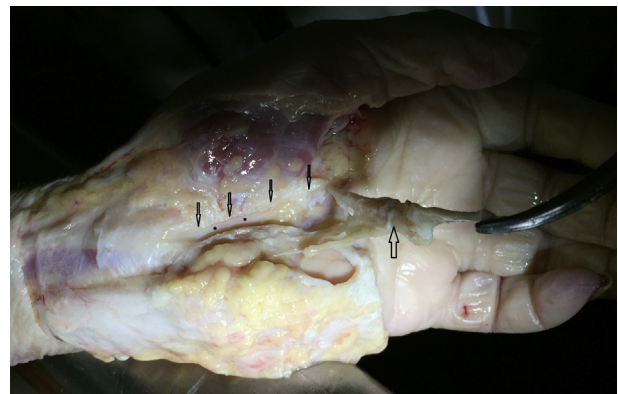


FIGURE 9: Complete TCL release with preservation of the antebrachial fascia and SupPA. For demonstration purposes, the intact antebrachial fascia and SupPA were cut and pushed aside during the dissection evaluation in order to show complete TCL release (arrows). Black dots, median nerve.

ultrasound image of a 27-g needle, with a diameter of 0.41 mm as a reference. Immediately after the procedures, all wrists were carefully dissected and visually assessed. The antebrachial fascia, the TCL, the SupPA, the median nerve and its branches, the ulnar and common digital nerves, the flexor tendons,

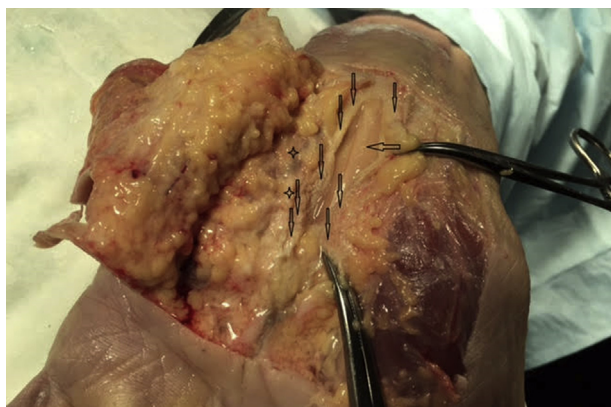


FIGURE 10: Complete TCL division shows preservation of the neurovascular structures. Dark stars, ulnar artery and SPA; thick arrow, median nerve; thin parallel arrows, edges of completely transected TCL.

the ulnar artery, and the SPA were all exposed and visually evaluated.

In all hands, a complete division of the TCL was accomplished (Fig. 8). The procedures performed using the modified technique showed preservation of the SupPA in all 5 wrists (Fig. 9). There were no neurovascular injuries to the SPA, to the Berrettini branch, or to other common digital nerves in any case (Figs. 10, 11). The entry site in the palmar skin port did not show any observable enlargement as a result of the thread sawing motion.

DISCUSSION

This cadaveric study shows that the modified TCTR technique is feasible and completely releases the TCL without damaging vital neural or vascular structures. The modified technique protects the SupPA as well as the Berrettini branch and common digital nerves.

The surgeon observes the anatomical structures using ultrasound imaging instead of direct visualization. Therefore, the correct interpretation of the ultrasound images is critical because the procedure requires a high level of precision and accuracy. In order to completely divide the TCL, a determination of the correct location for division is important. The distal margin of the TCL blends with the fibers of the thick, stiff deep palmar aponeurosis. Thus, the zone of potential median nerve compression may extend beyond the defined distal anatomical border of the TCL.^{5,7–11} Failure to transect this distal region has been blamed for some surgical failures.^{12–17}

Rojo-Manaute et al⁶ used the sonographic duck's beak as the distal edge of the TCL and applied it to the technique of carpal tunnel release with a very small incision. Their cadaveric study of 10 wrists showed

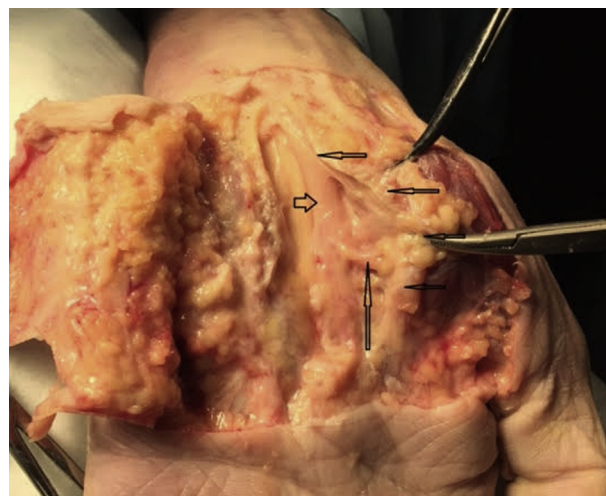


FIGURE 11: Complete TCL division with preservation of median nerve branches. Thick arrow, median nerve; thin long arrow, recurrent motor branch of median nerve; 4 parallel thin arrows, radial margin of fully transected TCL.

complete transection of the TCL for all the wrists. In the TCTR technique, the duck's beak was selected as the distal edge of division because it ensures the complete division of the TCL and is operationally feasible. The SPA and nerve branches are located 1 to 2 cm distal to the tip of the duck's beak, so correct needle placement and proper visualization with ultrasound are crucial.

The location of the proximal edge of the division is less sensitive because the neurovascular structures are relatively simple in the proximal wrist. It has been reported that the TCL is more proximal than traditionally defined.^{18–21} In order to obtain a sufficient release proximally,^{14,19,22} the needle exit point was made 2 cm proximal to the distal wrist flexion crease.

This modification of the TCTR preserves the SupPA. The palmar cutaneous branches of the median nerve lie superficial to the palmar aponeurosis and terminate in the skin. Some smaller, deeper branches of the palmar cutaneous nerve branches penetrate the aponeurosis, run on its undersurface, and terminate in the superficial aspect of the TCL.²³ The palmar cutaneous branches of the ulnar nerve lie superficial to the TCL and palmaris brevis.²⁴ Therefore, the preservation of the SupPA could avoid possible injuries to the subcutaneous superficial fasciae and the palmar cutaneous branches of the median and ulnar nerves.

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