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Percutaneous ultrasound-guided MANOS carpal tunnel release technique

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Abstract Ultrasound (US) is used with a minimally invasive cutting device to perform carpal tunnel release with a 3 mm wrist incision. US localizes tendons, arteries, and median nerve for safe introduction of the device into the wrist. The device is inserted in a blunt configuration under the flexor retinaculum, and a cutting wire is deployed that advances a 0.9-mm needle in the palm. The surgeon releases the flexor retinaculum from the inside out through the two skin punctures. Flexor retinaculum release is confirmed with US.

Keywords Carpal tunnel syndrome · Carpal tunnel release · Ultrasound · MANOS · Minimally invasive surgery

Introduction

Carpal tunnel syndrome (CTS) is a condition that affects almost 5 million US workers, 5.8 % of women and 0.6 % of men [12, 17]. It is one of the most common causes of occupational absenteeism and disability [10]. The condition has an estimated economic cost in excess of 2.8 billion a year [11]. It is therefore important to find an efficient and cost-effective method for treating CTS to allow for sooner return to work times.

Open carpal tunnel release (CTR) is the most commonly performed surgical procedure. The drawback is that the palm incision can result in short- and long-term pain and disability [1, 3, 4, 9]. Average return to work for open CTR is 54 days [15].

Endoscopic methods were developed in the 1990s [16], with the intention of decreasing postoperative pain and return to work times [2]. The mean return to work time for endoscopic CTR is 28 days [15]. However, endoscopic CTR has a narrow field of view and incomplete release, median nerve injury, and neurovascular tendon injuries have been reported [5, 7]. It has a steep learning curve and requires the use of costly equipment and a lengthy set-up time [7]. Adoption has been suppressed.

Ultrasound (US)-guided CTR has the potential to overcome the drawbacks of endoscope guided CTR. US provides a wide, high-resolution, view of the carpal tunnel anatomy [5, 6, 8]. It is inexpensive, readily available, and easily mastered. In a 35-patient series treated with US guided minimally invasive CTR in Japan, Nakamichi et al. reported less postoperative morbidity and high patient satisfaction compared to mini-open CTR [14]. To our knowledge, a minimally invasive US guided approach to CTR has not been clinically evaluated in the USA. McCormack et al. reported on a minimally invasive medical device for CTR, but relied primarily on nerve stimulation for guidance [13].

We describe our technique using US and a medical device called MANOS (MANOS CTR™, Thayer Intellectual Property, Inc., San Francisco, CA) for CTR, followed by three case reports.

Surgical Anatomy

The flexor retinaculum attaches to the hook of hamate and triquetrum on the ulnar side of the scaphoid and trapezium on the radial side. This forms the roof of the carpal tunnel, which is located on the volar aspect of the wrist. The median nerve and flexor tendons of the hand pass through the tunnel, except for the flexor carpi radialis, flexor carpi ulnaris, and palmaris longus [11]. Using the transducer in the vertical plane, the cross-sectional anatomy of the median nerve, ulnar nerve, ulnar artery, hook of hamate, flexor tendons, and flexor

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retinaculum can be identified as seen in Fig. 1. The hook of hamate is an important reference as it provides a landmark for safe placement of the MANOS device in relation to the median nerve.

Description of Technique

A 13-6 MHz transducer (Sonosite, Bothell, Washington, USA) positioned at the hook of the hamate and the tubercle of the trapezium was used to confirm safes zones of device insertion and to rule out a high bifurcation of the median nerve that may be better treated with open CTR. The transducer was moved distally to proximally to locate the median nerve, flexor tendons, ulnar artery/nerve, Guyon's canal, superficial palmar arterial arch, and to confirm left–right orientation of the transducer. The patients were asked to flex and extend their fingers and thumb while the distal wrist was scanned. Tendon and median nerve movements along the long axis of the wrist were observed.

The median nerve was seen above and ulnar to the flexor pollicus longus tendon and under the flexor retinaculum. The nerve had a constant mottled pattern compared to tendons, which appeared dark and light depending on the orientation of the transducer.

The initial cross-sectional area of the patients median nerve at the entrance to the carpal tunnel corresponding to mid-pisiform level was measured using the upper limit of normal of $<10\ mm^2$.

The patients' hands were prepped and draped on the MANOS Hand Board (MANOS CTR™ Hand Board, Thayer Intellectual Property, Inc., San Francisco, CA) in order to extend the wrist and provide easier access to the carpal tunnel. Wrist and thumb extensions also shifted the median nerve toward the radial aspect of the carpal tunnel. With endoscopic CTR, we routinely apply a well-padded pretested tourniquet (250 mmHg) to the proximal forearm to allow for the possible need to switch to an open CTR technique under tourniquet control. Tourniquet control is not required for the MANOS CTR technique and was not used in these cases. The entry point was 1.0 to 1.5 cm proximal to the distal wrist crease and just ulnar to the palmaris longus. The exit point of the MANOS device was marked using the Cardinal line of Kaplan and US (Fig. 2). 1 % xylocaine with epinephrine was injected just beneath the dermis at the entry and exit points.

A 3-mm transverse incision was made at the entry point, deepened just beneath the distal superficial forearm fascia to facilitate passage of a 3/4 mm Hegar Uterine Dilator probe (Hegar UT Dilat D/E ¾ MM, Sklar, West Chester, PA). The probe was inserted radial to the hook of the hamate along the most ulnar aspect of the carpal tunnel. The insertion trajectory was along the radial aspect of the ring finger ray. US confirmed proper probe placement. The patients were asked to individually move each digit to confirm that there were no tendons interposed, and no flexor tendons entrapped on the undersurface of the flexor retinaculum. The probe was withdrawn and the MANOS device was inserted and easily followed the path cleared by the probe. Device position was confirmed with US (Fig. 3). After correct placement was confirmed, the 0.9-mm distal end of the MANOS device was deployed at the pre-determined exit point at the intersection of Kaplan's line and the radial aspect of the ring finger ray via a thumb activated deployment feature. The wire was capped for safety (Fig. 4), and US again confirmed safe device placement as the patients were asked to individually move each digit prior to flexor retinaculum release.

Release was performed by moving the up-cutting MANOS device back and forth as down pressure to the ulnar-most aspect of the flexor retinaculum was applied (Fig. 5). Complete release of the flexor retinaculum could be felt, heard, and seen. Release was confirmed by viewing the device past the flexor retinaculum ultrasonographically (Fig. 6). The protective cap was removed and the device was withdrawn.

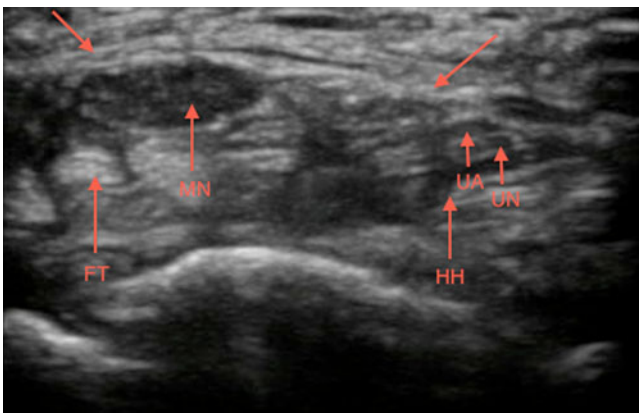

Fig. 1 Transverse view of the distal wrist and proximal aspect of the carpal tunnel, intraoperative image. *Open arrows* flexor retinaculum, *MN* median nerve, *FT* flexor tendons, *HH* hook of hamate, *UA* ulnar artery, *UN* ulnar nerve

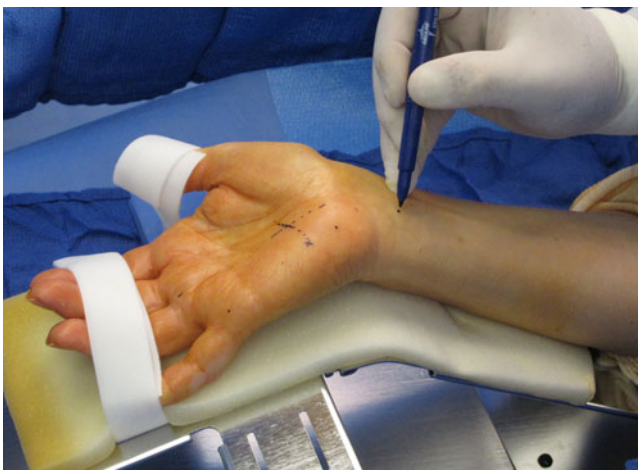

Fig. 2 Anatomical landmark mapping of the entry and exit points of the device

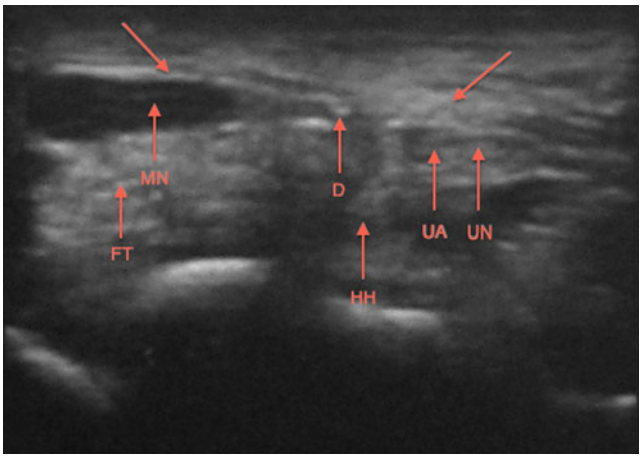

Fig. 3 View of MANOS device abutting the flexor retinaculum before cutting commences, intraoperative image. *Open arrows* flexor retinaculum, *MN* median nerve, *FT* flexor tendons, *HH* hook of hamate, *UA* ulnar artery, *UN* ulnar nerve, *D* MANOS device

The probe was re-inserted into the tract and complete release was confirmed again by cross-sectional and longitudinal ultrasonographic views of the probe past the flexor retinaculum (Fig. 7).

Throughout the procedure, the patients cooperated with our instructions to open and close the hand, individually activate the superficial flexors of the fingers and flexor pollicus longus, and to activate the thenar muscles by opposing the thumb tip to the digit tips (Fig. 8).

The entry incision was closed with DERMABOND (DERMABOND™, Ethicon, Inc., Somerville, New Jersey) (no sutures were necessary). We then applied a Reston™ (Reston™ Self-Adhering Foam Products, 3M, St. Paul, MN) padded forearm surgical dressing, keeping thumb and fingers free, wrist in 20° extension.

Postoperatively, the same procedure used to measure the cross-sectional area of the median nerve preoperatively was conducted.

Indications and Contraindications

US guided CTR with the MANOS CTR system is intended for patients with CTS that fail conservative therapy.

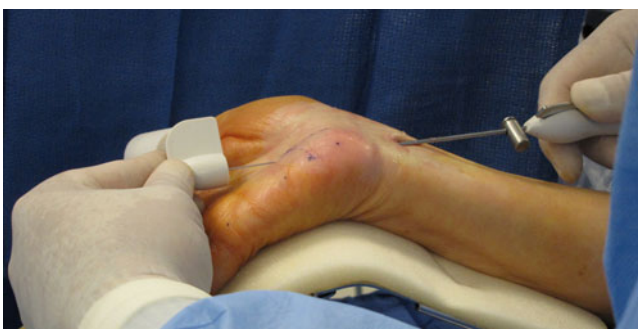

Fig. 4 Placement of safety cap on the MANOS device

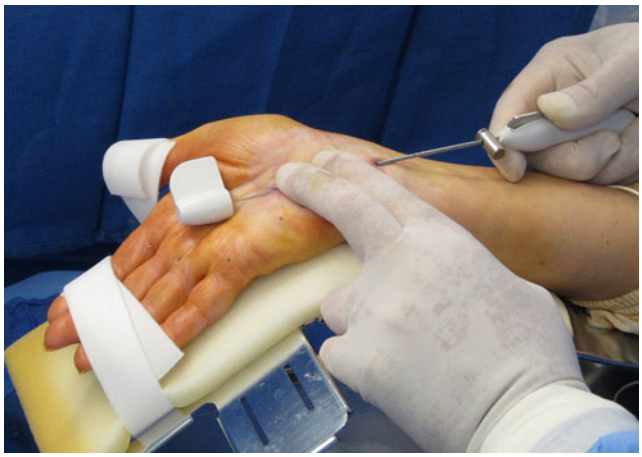

Fig. 5 Surgeon hand placement while actively cutting the flexor retinaculum with the MANOS device

Contraindications are wrist deformities that prevent safe insertion of the MANOS device, coagulation disorders, patients improving on conservative therapy, patients with no evidence of CTS, active or incompletely treated infection, unexplained pain in the hand or wrist, coexisting ulnar tunnel syndrome requiring minimal incision open technique release of carpal and ulnar tunnels, intra-carpal tunnel ganglion cyst or other space occupying lesions requiring open technique release and mass excision, bifid median nerve, inadequate space between the ulnar aspect of the median nerve and the hook of the hamate for safe probe/device insertion, persistent median artery occupying the ulnar aspect of the carpal tunnel, aberrant flexor digiti minimi brevis manus muscle or other anatomically varied muscle or tendon within the carpal tunnel contributing to median nerve compression, and/or hypersensitivity to any of the components of the product.

Post-op Management

A Reston™ sterile padded dressing is applied with the wrist in 20° extension for 3–5 days during which time the patient is

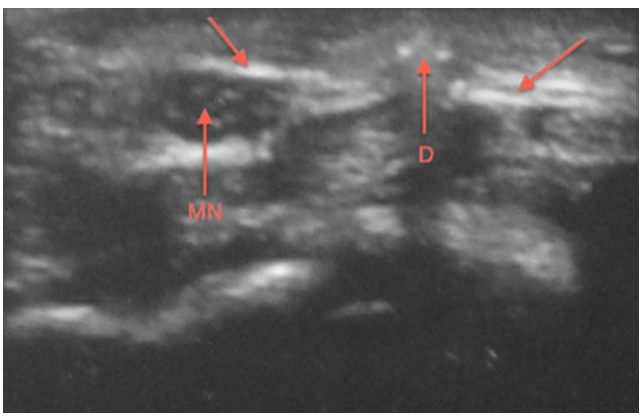

Fig. 6 Transverse view of the carpal tunnel following release of the flexor retinaculum, intraoperative image. *Open arrows* flexor retinaculum, *MN* median nerve, *D* MANOS CTR device

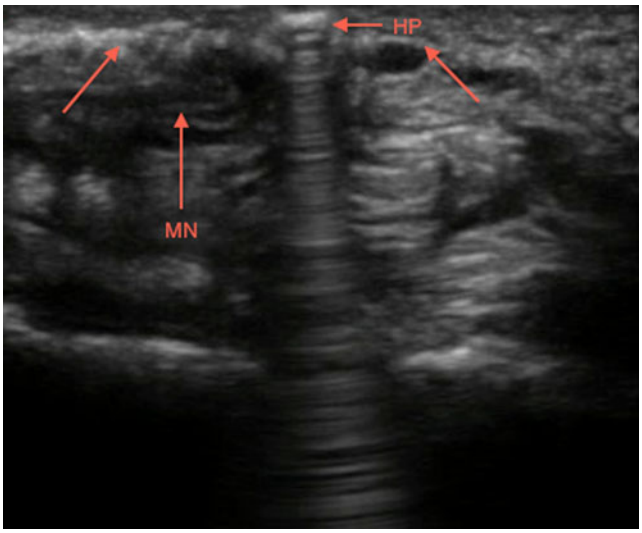

Fig. 7 Transverse view of the carpal tunnel following release of the flexor retinaculum, intraoperative image. *Open arrows* flexor retinaculum, *MN* median nerve, *HP* Hegar probe

encouraged to make light use of the hand. Patients typically return to normal manipulative use of the hand within 2 weeks and normal forceful use of the hand within 4 weeks.

Pearls and Pitfalls

This technique should only be used by surgeons who understand normal and varied anatomy of the carpal tunnel, have ample experience in the performance of open CTR, and have been certified in the use of the MANOS device.

Complications

Potential complications of the described technique include nerve, tendon, or vascular injury, incomplete release, and/or wound infection. Given the clear ultrasonographic imaging of the median nerve and the easy identification of the hyperechoic MANOS device, median nerve injury appears to be the least likely.

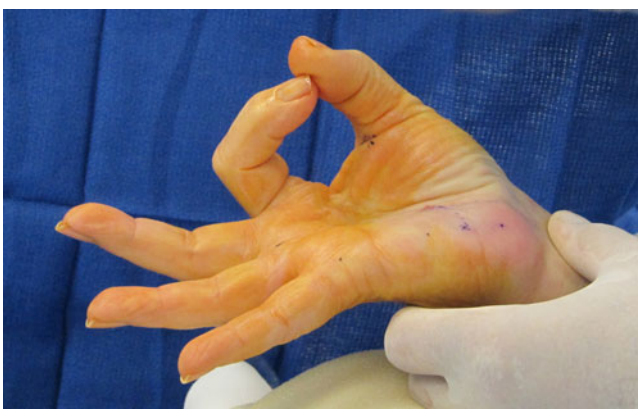

Fig. 8 Patient flexing fingers postoperatively

Brief Case Series or a Case Example

Patient-informed consent was obtained prior to performing the described technique. The procedures were performed under local anesthesia with/without conscious sedation. Postoperative narcotic pain medicine was not required in any of the cases, and all patients had a satisfactory postoperative progress, with a remarkable degree of early sensorimotor regeneration and remyelination.

Case 1

A 76-year-old female professional pianist presented with a 2-month history of acute electrodiagnostically confirmed severe left hand CTS. The patient had a 5-mm painless scapholunate dissociation with associated rotary subluxation of the scaphoid, distal scaphoid pole protruding into the carpal tunnel, which may have been the causative factor in the development and persistence of CTS. Preoperative grip and pinch strength was 30 lbs and 5 lbs respectively, and two-point discrimination was normal at 5 mm throughout the median nerve territory. She had mild softening of the thenar musculature without clear-cut atrophy, as well as decreased sweating throughout the median nerve territory. Her preoperative left median nerve cross-sectional area was 11 mm^2.

The patient underwent left CTR with the described technique, and had no pillar pain or tenderness postoperatively. Significant improvement in left hand sensibility was reported within 24 h of surgery. She returned to playing the piano 3 weeks after surgery. Her CTS symptoms had resolved, and follow-up office ultrasonography confirmed that her median nerve cross-sectional area was well within normal limits at 7 mm^2.

Left grip and pinch strength improved above baseline values by 9 weeks postoperatively; 40 and 11 lbs respectively. Two-point discrimination remained normal at 5 mm throughout the median nerve territory. The patient had full return of thenar muscle bulk and power, and normal return of sweating in the median nerve territory.

Case 2

A 74-year-old retired male exercise enthusiast presented with a 6-month history of electrodiagnostically confirmed right CTS, and right C5 cervical radiculopathy. The patient had transient benefit from minidose injection of steroid into the carpal tunnel but symptoms recurred indicating the obvious

need for right CTR. Preoperative grip and pinch strength was 60 and 30 lbs, respectively, and two-point discrimination was normal at 5 mm throughout the median nerve territory. He had normal thenar musculature, and increased sweating over the little finger confirming some denervation in the median nerve territories since sweat fibers parallel sensory fibers and peripheral nerves. His preoperative right median nerve cross-sectional area was 10 mm^2.

The patient underwent right CTR with the described technique, and returned to lifting weights 21 days after surgery. Pillar pain was not reported. The patients CTS symptoms had resolved, and follow-up ultrasonography confirmed that his median nerve cross-sectional area was well within normal limits at 7 mm^2.

Right grip and pinch strength improved above baseline values by 3 weeks postoperatively; 75 and 32 lbs respectively. Two-point discrimination remained normal at 5 mm throughout the median nerve territory. The patient had normal return of sweating in the median nerve territory.

Case 3

A 65-year-old male concert violinist presented with a 1-year history of electrodiagnostically confirmed severe left hand CTS. Preoperative grip and pinch strength was 60 and 17 lbs, respectively, and two-point discrimination was normal at 5 mm throughout the median nerve territory. He had mild softening of the abductor pollicis brevis, and decreased sweating over the left thumb, long, and ring fingers. His preoperative left median nerve cross-sectional area was 14 mm^2.

The patient underwent left CTR with the described technique, and reported definite early improvement in sensibility and returned to playing the violin within 1 week of surgery. The patient did not experience any pillar pain, and follow-up ultrasonography confirmed that his median nerve cross-sectional area was well within normal limits at 8 mm^2.

Left grip and pinch strength improved above baseline values by 3 months postoperatively; 63 and 18 lbs respectively. Two-point discrimination remained normal at 5 mm throughout the median nerve territory. The patient had normal return of sweating in the median nerve territory.

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Statement of Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study.

Conflicts of Interest REM declares that he has no conflict of interest.

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