

A Review of Advances in Carpal Tunnel Release

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ABSTRACT

There have been many advances in recent years in peripheral nerve releases and most notably those involving median nerve entrapment at the wrist. This mini-review article focuses on the advances within the past five years in minimally, percutaneous, and ultra-minimally invasive techniques for carpal tunnel release. The progress in these surgical techniques has been made in part by the improvements in real time sonographic imaging. With each surgical technique, we look at the pre-clinical and clinical data and any complications from or limitations with these procedures. It is our aim with this article to spark discussion and spur innovation regarding ultrasound guided carpal tunnel release that can be applied to other peripheral nerve entrapments.

In the past five years, the surgical techniques to perform carpal tunnel release continue to advance. Among these surgical techniques is a growing trend towards less invasive methods and increased utilization of ultrasound guidance. In the literature, the list of methods includes open release, endoscopic release, minimally invasive release, percutaneous release, and ultra-minimally invasive release. These progressively less invasive techniques take advantage of the major improvements in both ultrasound image quality and real-time definition. This mini-review examines various surgical techniques involving minimally invasive, percutaneous, and ultra-minimally carpal tunnel release with emphasis on the development of techniques that are increasingly less invasive and more reliant on high-quality ultrasound imaging.

MANOS

In 2012, McCormack et al. performed 52 carpal tunnel releases using the MANOS device guided by a nerve stimulator¹. In this study, the 2.1 millimeter MANOS device is passed through the carpal tunnel and a serrating wire is used to transect the transverse carpal ligament. In two follow-up case series examining a total of 6 patients, the MANOS surgical release technique was documented to be improved by utilizing ultrasound guidance^{2,3}. Despite these developments, several complications have been documented.

Complications

Six patients had inadvertent skin lacerations at the entry and exit point. Two patients were treated with oral antibiotics for wrist puncture site redness and swelling which resolved. One had persistent wrist swelling for 3 months. One had a pulling sensation in the index and long fingers which resolved. One had dorsal thumb numbness which resolved at 3 months. Four patients had poor outcomes. Of these poor outcomes,

one patient had persistent hand numbness and tingling 2 weeks after surgery and had an open exploration within one month that showed incomplete release of the distal third of the transverse carpal tunnel ligament.

“V” blade

In 2012, de la Fuente et al. described the use of a “V”-shaped scalpel used in the surgical release of the transverse carpal ligament. This cadaveric study of twenty specimens requires an initial transverse incision to insert a blunt probe with a “U”-shaped trough allowing for confirmation of the distal border of the flexor retinaculum. Then, the “V”-shaped meniscomote, with a 5mm gap between blades, is inserted and used to transect the transverse carpal ligament. In this study, there was complete release of the transverse carpal ligament and no injuries to the neurovascular bundles although one specimen required a second pass of the “V”-shaped blade to completely transect the flexor retinaculum⁴.

Percutaneous Needle Release

McShane et al. reported in 2012 a surgical release technique whereby an 18-gauge needle is used to repeatedly fenestrate the transverse carpal ligament ulnar to and parallel with the median nerve. Post-procedure betamethasone and lidocaine were then administered. Thirty-six patients received this procedure in this retrospective preliminary study. With a response rate of less than 50%, eighty-four percent of patients stated that they received satisfactory results⁵.

Hook Knife

In 2014 and 2015, Chern et al. describe a method of transecting the transverse carpal ligament using a hook knife. In the cadaveric study, 18 of 20 specimens were completely released with no neurovascular bundle injuries. This preclinical study was followed up with a preliminary case series of 91 patients. During this prospective case series, two cases were deemed unsatisfactory including one with moderate wrist pain and one with recurrence of carpal tunnel syndrome. One major limitation noted by the authors was the advanced skill required in performing ultrasound guidance^{6,7}.

SX-One MicroKnife™

In 2016, a new company, Sonex Health, developed the SX-One MicroKnife™. This procedure begins with sonographic visualization of relevant anatomic structures. The SX-One MicroKnife™ is inserted into the wrist through a 4-5 mm micro-incision. Protective bumpers are inflated to create a safe zone between the blade and the nearby tendons and neurovascular structures. The transverse carpal ligament is cut and then the blade is returned to its inactive position. The initial incision may be closed with an adhesive bandage, surgical glue, sutures or stitches if

necessary. Approximately 70 cases have been performed using this method without complications as reported in the Sonex Health newsletter⁸.

CarpX

In 2017, PAVmed’s CarpX™ applied to gain clearance from the FDA according to a June 2016 press release. The CarpX™ is a balloon catheter with an integrated bipolar radiofrequency cutting electrode. It is guided into the carpal tunnel percutaneously over a guidewire without an open surgical incision. Positioning is confirmed by ultrasound and similar to the SX-One MicroKnife™ a protective balloon is inflated which protects vital structures from the cutting electrodes. These radiofrequency electrodes are then used to cut the transverse carpal ligament. In 2016, a non-peer reviewed press release reported completion of a preclinical study with an aim to publish in a peer reviewed journal. This press release reports that of the 14 patients, all transverse carpal ligaments were cut cleanly and without cauterization or injury to vital structures⁹.

Thread Carpal Tunnel Release (TCTR)

Recently, Guo et al. described a method of releasing the transverse carpal ligament using a nonserrating thread. The thread carpal tunnel release is a surgical technique involving a non-serrating, echogenic metal thread that is capable of being looped around the transverse carpal ligament and transecting this ligament¹⁰⁻¹².

Clinical outcomes

To date, there have been 492 hands operated in the office with local anesthesia (Table 1). There were no neurovascular complications with up to 28 months of follow-up. Significant relief of symptoms is noted within 24 hours in most cases. Patients with office jobs are able to return to work on postoperative day 1, and those with jobs involving more vigorous manual activities return to work in about two weeks¹².

What are the steps in performing the procedure?

This multi-step procedure involves first identifying sonographic landmarks such as the proximal and distal boundaries of the transverse carpal ligament and palmar fascia; the recurrent motor branch to the thenar muscles; the Berrittini sensory nerve when present; the third digital nerve; and the superficial palmar arch artery. After sonographic identification of these important structures to preserve and surface skin marks are made with a marking pen, then the second step involves guiding a spinal needle beneath the transverse carpal ligament through the carpal tunnel under ultrasound guidance. This step is made easier by hydrodissection with 1% lidocaine under ultrasound guidance which prevents iatrogenic injuries to the median nerve or surrounding tendons. The third step involves

Table 1:

Name	Authors	Device	Skin incision	AD	Cases	Complications
Manos	McCormack et al. 2012	2.1 mm serrating wire	3mm	NS, U/S	Clinical: 52	6 skin lacerations. Four with poor outcomes.
"V" blade	de la Fuente et al. 2012	"V" scalpel	NA	U/S	Cadaver: 20	One required second pass.
Percutaneous needle release	McShane et al, 2012	18-gauge needle fenestrated	None	U/S	Clinical: 36	Response rate <50%. 84% satisfactory results.
Hook Knife	Chern et al; 2014 & 2015	Hook knife	None	U/S	Cadaver: 20 Clinical: 91	One with moderate wrist pain. One with recurrence of CTS.
SX-One MicroKnife™	Sonex Health, 2016, Newsletter	Balloon catheter with central blade	4-5 mm	U/S	Clinical: 70	None
CarpX	PAV meds, 2016 Press Release	Balloon catheter with RF cutting electrode	None	U/S	Cadaver: 14	None
Thread Carpal Tunnel Release (TCTR)	Guo et al, 2015, 2016, 2017	18-gauge needle and thread	None	U/S	Cadaver: 35 Clinical: 492	No neurovascular complications.

Description: NS: nerve stimulator; U/S: ultrasound

passing the thread through the spinal needle. After the metal thread is passed under the transverse carpal ligament, a second pass over the transverse carpal ligament occurs using the same entry and exit points from the initial pass. The thread is again passed through the spinal needle which when pulled taut forms a loop around the transverse carpal ligament. The ability to confirm the correct placement of the thread without looping unintended adjacent structures is made possible by ultrasound guidance and visualization. This confirm-then-cut method of ultra-minimally invasive surgery is important in preventing iatrogenic injuries.

Future Studies

The thread surgical release technique has been expanded from carpal tunnel release to trigger finger release. Ongoing investigations are pursuing the thread surgical release's clinical efficacy and safety in use for cubital tunnel release, tarsal tunnel release, plantar fascia release, release for DeQuervain's tenosynovitis, common peroneal nerve release, and fascial release for compartment syndrome and plantar fasciitis.

Conclusion

In conclusion, so far, only TCTR is the ultrasound guided ultra-minimally invasive procedure with multiple clinical and cadaveric studies published demonstrating both effectiveness and safety. This surgical technique has also been cross applied to other surgical releases such as trigger finger with similar excellent results¹³.

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