Sonography-Guided Carpal Tunnel Release

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KEYWORDS

• Carpal tunnel syndrome • Interventional ultrasonography • Minimal invasive surgical procedures
• Ultrasound-guided surgery

KEY POINTS

- This is a new technique for carpal tunnel release thanks to recent improvement in the quality of ultrasound devices.
- The surgical technique is well described and consists in a wrist approach in a retrograde fashion under strict ultrasound control to transect completely the transverse carpal ligament.
- Outcomes of the first 150 patients, tips and tricks are presented and discussed.
- With a dedicated instrument, this is a safe and well-tolerated procedure, efficient, costless.

Video content accompanies this article at http://www.hand.theclinics.com.

PREOPERATIVE CONSIDERATIONS

Carpal tunnel syndrome (CTS) is one of the most common neuropathies of the upper limb, and affects mainly manual workers. Its prevalence is approximately 5% of the population, and usually is diagnosed in the last active years (50–60 years old), with an increased incidence in women (4:1). Atroshi and colleagues[1] showed that the overall prevalence of neuropathy signs in the median nerve distribution is 14.4% (95% CI, 13.0%–15.8%).

They also determined that clinically certain CTS prevalence confirmed by electrodiagnostic tests (4.6% for women and 2.8% for men) was close to or somewhat lower than the true prevalence. CTS diagnosis is clinical, with typical symptoms including paresthesia, pain, and weakness in the median motor nerve distribution, often increasing in intensity at night. Ultrasound (US) and electromyography are used as means of additional evaluation and in poor clinically defined cases, if a differential diagnosis is needed. Once a diagnosis is confirmed, either medical or interventional treatment strategies can be used, the choice depending on the severity of the condition and the patient's decision. Among accepted severity criteria, authors find permanent amyotrophy of the thenar eminence due to its interrupted median nerve innervation, paralysis of thumb opposition, permanent paresthesia, and all forms of hyperalgesia.[2] For severe CTS patients (presence of clinical criteria, activity limitations, presentation of poor prognosis factors, and decreased quality of life) and for those who medical treatment failed, interventional options are preferred.[3,4]

SURGICAL TREATMENT OPTIONS

Surgery in CTS traditionally has been performed by an open approach carpal tunnel release (OCTR), but in the past 2 decades, many have opted by an endoscopic approach carpal tunnel release, owing to its reported advantages of reduced postoperative pain and rapid resumption of daily activities.[5–8] Nevertheless, the decision between endoscopic or open carpal tunnel release usually is based on surgeon and patient

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preferences.[2] Another available option is the mini–open carpal tunnel release (miniOCTR), which emphasizes all minimally invasive advantages compared with OCTR and is superior concerning early postoperative pain.[9–11] These minimally invasive techniques present some disadvantages, including elevated cost of endoscopic equipment, the partially blind section of the retinaculum when carrying out miniOCTR, and the experience needed to operate the endoscope.

Over the past few years, the quest for an equally safe and effective alternative to OCTR has continued. Sonography long has been used for anatomic and severity assessments in patients with clinical CTS,[12–14] and the idea of CTS treatment under sonography guidance had its first clinical application in 2012,[15–17] although an attempt with its use already had been published in 1997. Sonography recently has been validated as a tool for accurate identification of vital anatomic structures and deemed safe for transverse ligament resection.[18] Efficacy of the transverse carpal ligament (TCL) section and percentage of postoperative complications have been shown to vary depending on the type of instrument used to carry out the procedure.[18–21]

After the development of a compact, easy-to-use scalpel for CTS surgical treatment, the author hypothesized that its use under US guidance would provide similar efficacy and tolerance compared with other CTS surgical treatment techniques. The main clinical outcome was the evaluation of grip strength 1 month after sonography-guided TCL release. The secondary endpoints included postoperative pain, persistence of nocturnal paresthesias, and resumption of daily work and driving activities as well as postoperative complications and subjective satisfaction.

AUTHOR EXPERIENCE

The present study was designed as a descriptive uncontrolled retrospective study (open label, single arm). This registry was carried out on 150 adult patients subjected to US-guided minimally invasive carpal tunnel release, completed with a new ligament transecting device. Participants' inclusion took place after clinical confirmation CTS. Inclusion criteria consisted of presence of a clinical syndrome (distal paresthesias in the median serve distribution areas, nocturnal numbness, weakness or atrophy of the thenar musculature, Tinel sign, positive Phalen test, and loss of 2-point sensory discrimination),[22] failure of medical management, and severe CTS at electromyography. Patients were excluded if another associated procedure was to be performed simultaneously or if the patient presented with additional upper limb pathology.

SURGICAL TECHNIQUE

All patients were operated on by the same orthopedic surgeon, specialized in hand surgery, and in similar operating room conditions. Once the patient was installed on the interventional table, with arm and forearm adequately positioned on a rest platform, the operator used a standard US probe (18 MHz) to adjust US parameters and mark the carpal tunnel limits (**Fig. 1**, Video 1). The first step concerned the setup, including the recommended cutaneous asepsis following by sterile drapes positioning. A tourniquet is useless. In this way, pulsing ulnar artery is easy to notice. Local anesthesia was carried out by the infiltration of 2-mL lidocaine, from 2 cm proximal of the wrist flexion line up to the distal limit of the volar transversal carpal ligament, completed by a regional ulnar and median nerve block at the forearm. The second step allowed the sonographic exploration in order to check all the different anatomic elements and variations. The third step focused on the section of the ligament and its control. The surgeon proceeded with a 3-mm to 5-mm transverse incision proximal to the wrist flexion crease, after the patient was completely insensible to local pain stimulus. Dissecting scissors were used to create an introduction path for a novel retrograde scalpel, specially designed for carpal tunnel release (Surgicut Ortho Release, reference ASOR12, Aspide Medical, La Talaudière, France) (**Fig. 2**). No trocar was required to gain access. At this point, US guidance was used to ensure that the mandrel protecting the scalpel was positioned correctly under the TCL inside the carpal tunnel, radially by the median nerve, and ulnarly by the hook of the hamate and ulnar vessels corresponding to the transverse safe zone. Once the device was in place, the protecting sheath was retracted and the scalpel was visualized. The surgeon placed it in horizontal position and progressed up to the hamate bone, which constituted the distal anatomic reference for ligament release. Finally, the cutting edge was placed vertically, and the TCL was transected completely in retrograde fashion, under strict US control. After the completion of this maneuver, the surgeon sheathed the scalpel and confirmed complete ligament section by US. Cutting steps were repeated if an incomplete section was observed. Once the device was removed, access incision was closed with a simple subcutaneous absorbable suture.

OUTCOMES

All parameters were registered during preoperative and at 1-month follow-up appointments. At

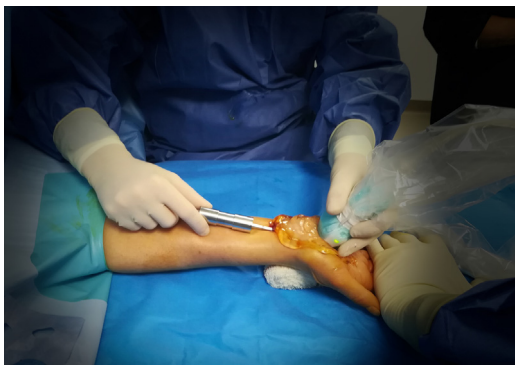

Fig. 1. External intraoperative image shows device placement.

inclusion, demographic data (age, gender, dominant hand, operated side, and degree of workload on professional activity) were obtained. Workload groups were built based on criteria accepted by the French High Authority for Health. Patients thus were placed in 1 of 4 groups: retired or currently unemployed (no workload), light workload (point load <10 kg, repeated load <5 kg), moderate workload (point load<25 kg, repeated load <10 kg), or heavy workload (point load >25 kg). To establish procedural efficiency, grip strength was analyzed before and at 1 month after surgery. Measurements were standardized by the use of a palmar dynamometer (Jamar Hydraulic Hand Dynamometer) and repeated 3 times per test in order to obtain an average of values, expressed in kilogram-force. Analysis reflected the percentage of postoperative grip strength recovery compared with preoperative values.

In parallel, data on postoperative pain were obtained on a standardized 1 to 10 visual analog scale. Time to nocturnal acroparesthesia resolution, and time to resumption of daily and work activities as well as driving also were registered. These were expressed as mean and SD values. Patients' subjective satisfaction regarding functional improvement was assessed on a scale of 1 (extremely unsatisfied) to 10 (extremely satisfied). Any procedure or suture related complications also were noted.

All parameters were analyzed using SPSS Statistical Package for the Social Sciences (IBM Corp. Released 2013. IBM SPSS Statistics for Mac, Version 25.0). Data were expressed as median and range of values, unless otherwise noted. Wilcoxon signed rank test was used for comparison between initial and final results of nonparametric variables, and Mann-Whitney *U* test or chi-square test was used for comparison of numerical or categorical data, respectively, between independent groups. Time to event was depicted graphically by means of a Kaplan-Meier (one minus survival) curve for resumption of daily activities, work, and driving. This retrospective study was approuved by the ethics committee where patients were treated. After diagnosis, each patient was presented with different therapeutic options, and an informed consent form was voluntarily signed by those accepting the sonography-guided transverse ligament release.

RESULTS

Included in this study were 150 patients, aged between 23 years old and 88 years old (median: 59 years old). Data on gender, operated and dominant hand, and level of workload are expressed on **Table 1**. A significant majority were women ($P = .03$), and there were significant differences in terms of workload level per gender, with a strong correlation between the 2 (Spearman rho = 0.61). Of the 49 employed women, 38

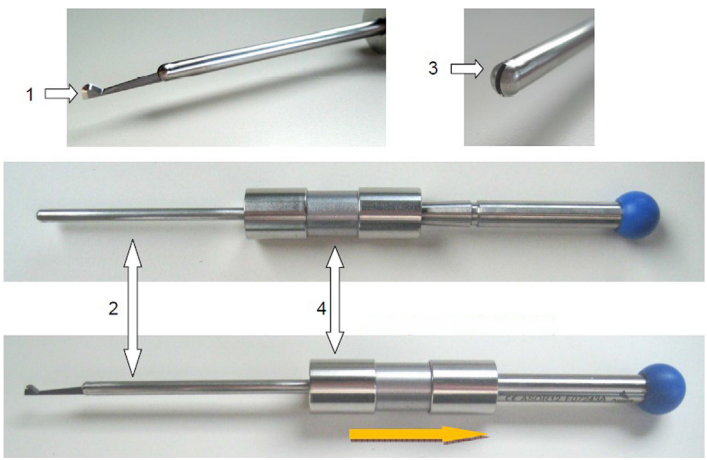

Fig. 2. External image shows the device and the cutting blade deployed (1, the blade; 2, the protecting sheath; 3, the slot of the sheath when the blade is inside; and 4, the central part of the device able to slide the blade out). Yellow arrow indicates the sliding direction of the device in order to go out the blade.

Table 1
Patient data

Studied criteria	Men	Women	All Patients (n = 150)
Gender, n (%)			
Men	—	—	55 (36.7)
Women	—	—	95 (63.3)
Age, median (range), y	60 (23–87)	58 (26–88)	59 (23–88)
Operated side, n (%)	*Dominant hand, n (%)*		
Right, n = 78 (52.0)			
Right	26 (47.3)[b]	46 (48.4)[b]	72 (48.0)
Left	2 (3.6)[b]	3 (3.2)[b]	5 (3.3)[b]
Ambidextrous	1 (1.8)[b]	—	1 (0.7)
Left, n = 72 (48.0)			
Right	24 (43.6)[b]	39 (41.1)[b]	63 (42.0)
Left	—	7 (7.4)[b]	7 (4.7)
Ambidextrous	2 (3.6%)[b]	—	2 (1.3)
Level of work charge, n (%)			
Light	5 (9.1)[b]	10 (10.5)[b]	15 (10.0)
Average	6 (10.9)[b]	38 (40.0)[b]	44 (29.3)
Heavy	15 (27.3)[b]	1 (1.1)[b]	16 (10.7)
Not applicable[a]	29 (52.7)[b]	46 (48.4)[b]	75 (50.0)

[a] Retried or without current professional activity.
[b] Percentage on similar gender population.

(77.5%) reported a moderate workload and only 1 (2%) a heavy workload, whereas of the 26 men still leading an active work life, 6 (23.1%]) stated a moderate workload and 15 (57.7%) had heavy workload functions ($P<.01$); 135 patients (90%) were right-handed but no differences were found between operated sides.

Median preoperative grip strength was estimated at 19.50 kgf (2–58). At 1 month postoperatively, subjects had recovered 73.7% (20%–650%) of the initial force, with a vast majority of participants exerting between 60% and more than 100% of their preoperative grip power (113 participants [75.3%]), as depicted in Fig. 3. A significant difference was found between preoperative and 1-month postoperative grip testing ($P<.01$).

Concerning immediate postoperative pain, 96.7% of subjects reported mild interference with functioning (visual analog scale 0–3), with more than 70% experiencing no pain. There were 4 patients with a visual analog scale of 4 (moderate pain),[23] 3.3% of the studied population.

Regarding the persistence of nocturnal acroparesthesias, only 1 patient (0.7%) reported persistent tingling of the distal extremities of the fingers after the first postoperative month.

Resumption of daily activities occurred for 90% of the patients at day 8. For 90% of the active population, work resumed 2 weeks after the procedure. Of the studied population, only 119 still were active drivers, and all were driving by the end of the first month of recovery (Fig. 4).

Among the patients, 71.9% were highly satisfied and 26.0% were satisfied with the postoperative final result. Three patients found that they were not entirely satisfied and attributed a score of 6 to the final result. No grade under 6 was attributed in this group of patients.

There were 3% reported complications on the first postoperative month, which included bilateral C6 cervicobrachial neuralgia (1 case), internal scar fibrosis (1 case), and hamate bone pilar pain (2 cases). Additionally, 7 patients presented with an inflammatory granuloma in reaction to suture material, 1 patient reported loss of sensibility, and another had sensitive incision scarring. No perioperative complications or difficulties were reported by the operating surgeon.

DISCUSSION

At the end of the follow-up period, significant recovery of grip strength was observed in the studied population. Additionally, pain and acroparesthesias resolved promptly after surgery, normal activities took less than 2 weeks to resume for a large majority of patients, and no serious complications were observed during the first postoperative

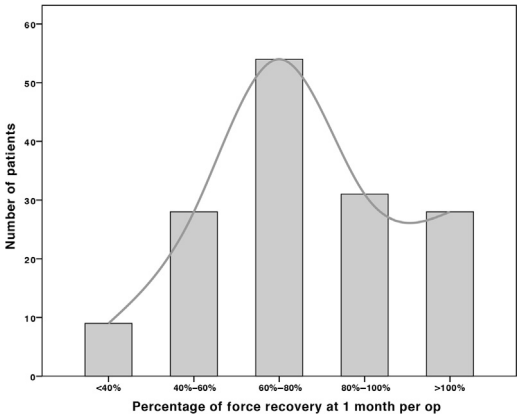

Fig. 3. Postoperative grip, 1 month. per op, per operative.

month. Procedural subjective satisfaction was high in approximately 98% of operated patients, indirectly reflecting good tolerance and functional results of US-guided release of TCL using a new compact scalpel.

Although grip strength and hand muscle atrophy are considered objective parameters reflecting functional status, there still are studies that do not measure and compare its preoperative and postoperative values. Besides, available reports often are contradictory regarding recovery of grip strength after transverse ligament release[16,24,25] When carrying out this study, it was judged unnecessary to use reference values for average grip strength[26] because they depend on numerous individual factors, such as subjects' age, current work activity and history, of manual efforts. Furthermore, because the study was retrospective, it lacked data to perform adequate comparison with published reference values, so it was decided to compare preoperative and postoperative values in order to determine functional outcome for this specific group of patients. The

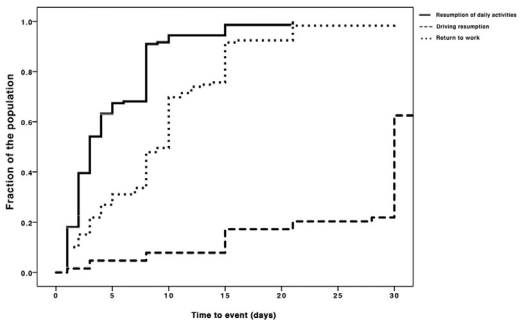

Fig. 4. Resumption of daily activities, driving and return to work postoperatively.

author observed a median recovery of ,greater than 60% of the preoperative grip strength for more than 75% of the patients at 1 month postoperatively, which reflects a significant improvement on functional status after percutaneous median nerve decompression. Moreover, the population showed excellent procedural efficacy regarding CTS acroparesthesia resolution, because only 1 of the patients experienced persistence of nocturnal tingling of the distal extremities of the fingers at the end of the follow-up period. The results are superior compared with the latest report by Petrover and colleagues,[27] who observed that 6 months after the surgery, 12% of their patients still presented with persistent paresthesia in the median nerve distribution. The use of US as an ancillary tool in CTS treatment allows for simultaneous visualization of TCL, median nerve, ulnar vessels, and the release instrument, which constitutes a clear advantage over endoscopic techniques.[18,20] In the study, a novel retrograde scalpel was used, specially designed for percutaneous carpal tunnel release, which allows for an incision reduction of up to 3 mm with simultaneous complete section of the TCL in all cases. Burnham and colleagues[18] and de la Fuente and colleagues[19] also performed minimal incision percutaneous releases with different tools and under US guidance. The first study was carried out on cadavers, impairing sonography vessel visualization and leading to overcautious section maneuvers, which increased the risk of incomplete release of the TCL with subsequent increase in CTS recurrence. Additionally, they used a threaded cutting loop with probable inferior stability compared with the author's scalpel. In the series, no remaining fibers were detected by US imaging on perioperative control after TCL section. No recurrences of CTS symptoms were observed during the follow-up period. de la Fuente and colleagues used a bulkier probe and a scalpel system that, although effective and without iatrogenic risks, required a larger skin incision with higher risk of scar pain and lower patient satisfaction, reducing advantages of a sonography-guided minimally invasive percutaneous approach.

Other surgical teams operating with a similar approach confirm that a retrograde section of the TCL through a proximal approach provides a safer and easier method of median nerve decompression, with excellent scar tolerance (less fibrous tissue and lower pressure compared to palmar incisions).[20,28] Observed tolerance and pain reduction probably led to an earlier return to work and a faster resumption of daily activities. Almost all patients in the study were observed carrying out normal daily activities on the first week

after surgery and returning to work before the end of the second postoperative week. Rojo-Manaute and colleagues[29] reported a lower average for the resumption of daily activities, whereas Wang and colleagues[30] reported slightly superior delays on a study focusing on bilateral transverse ligament releases. Other investigators reported even longer sick leave periods.[31,32] This parameter is highly dependent on workload and surgeons' recommendations and difficult to compare between studies. In the author's practice, the author commonly advises a minimum leave of 2 days to 8 days, depending on expected workload, with reevaluation of period extension if needed. Patients usually are cautious after being subjected to TCL release, and some investigators even advise avoidance of any firm grip gesture before 6 weeks,[4] but in the author's case no such recommendations were made. Nevertheless, it was not until the end of the follow-up period that all the driving patients resumed the handling of steering wheels.

This has led to considering the importance of a more accurate evaluation of the reasons behind such a long delay as well as the need to determine what are the correct and advisable periods for resumption of activities after this procedure.

Failure of CTS surgical treatment is related not only to syndrome severity but also especially to delayed treatment leading to irreversible median nerve damage and even complex regional pain syndrome (CRPS).[4] In the author's study, all operated cases were diagnosed correctly and managed before irreversible nerve lesions appeared. Overall, excellent functional results are reported, associated with absence of pain in all patients at the end of the first postoperative month.

Bickel[33] published in a 2010 review, in which he concluded that patient satisfaction, and clinical as well as functional improvement after carpal tunnel surgery generally are quite high. Regarding subjective satisfaction, approximately 98% of the author's patients were satisfied with the procedure, similarly to other reports in the literature.[28] The few patients who were less satisfied presented with an inflammatory scar, which slightly decreased postoperative comfort. This was resolved in the months following the end of the study period.

Usual complications of carpal tunnel surgery include nervous, vascular, or tendinous damage; infections; and transient neurologic disturbances or CRPS. According to a recent state-of-the-art review on sonography-guided carpal tunnel surgical release, other investigators have seen complication rates decreasing significantly when using this technique, especially for what concerns postoperative infection and CRPS.[34] The author reported 3 patients with CTS-related complications in the first postoperative month and no perioperative difficulties nor complications.

> Further investigation and longer follow-up period are necessary to determine the degree of implication of the US-guided procedure or the use of the novel TCL section instrument. The low percentage of postoperative complications, however, along with a surgical approach that allows for quick resumption of daily and work activities render the reported technique attractive in terms of overall patient benefit and costs. As suggested by other investigators,[34–36] authors currently are pursuing research to prospectively determine interventional times, postoperative complications, and functional outcomes in a new series of patients with a longer follow-up period and simultaneously establishing validation for its performance outside the operating room, further reducing treatment costs and increasing the technique's availability.

This is a retrospective study on cohort of 150 patients (level of evidence C). This report also is limited by the number of patients and by a short follow-up period. Concerning the latter, a longer follow-up could be of benefit to analysis, because further improvement over time is expected and later follow-up visits should show better functional status. With only 4 weeks of postoperative evaluation, CTS recurrences are impossible to determine. Another limitation resides in that all procedures were carried out but a single experienced operator limiting universal application of the technique. Results ideally should be confirmed by a randomized multicenter controlled trial evaluating safety and efficacy of percutaneous carpal tunnel release versus other standardized surgical approaches (open or endoscopic). Other parameters, such as hand muscle atrophy and recovery and relationship between section of TCL and recurrence of CTS, also would be useful to validate this technique further. US guidance constitutes a readily available, inexpensive, fast, and painless ancillary tool for carpal tunnel release, with the added advantages of intraoperative anatomic and lesion assessment. The author's results show that US-guided surgery for CTS using a novel retrograde scalpel is an efficient, well-tolerated procedure, which potentially will reduce treatment costs for CTS due to increased safety, by providing controlled median nerve releasing maneuvers, a faster recovery, and fewer complications. Randomized prospective studies on learning curve and procedural efficiency and

tolerance on a larger patient series should be pursued in order to establish certainty of reported benefits.

Since this study, more than 1000 patients have been operated on by the same hand surgeon and the same procedure. Stiches now are useless and 3 adhesive tapes (Steri-Strips) are enough to close the wound avoiding an inflammatory granuloma. That is the only modification of this procedure.

CLINICS CARE POINTS

Pearls

- Explore with the probe the entire anatomic structures of the carpal tunnel before starting the procedure.
- Check the correct position of the device between the median nerve and the ulnar vasculonervous structures without flexor tendon interposition. Sometimes, the device has to be correctly reintroduced.
- Put the wrist in extension to place flexor tendon as deep as possible in the carpal tunnel.

Pitfalls

- If the antebrachial fascia is not open, the device will not be in a correct situation and not slide along the flexor tendon
- If the scalpel used for skin incision goes deeper, section of a superficial flexor tendon may occur.
- Without a second look after ligament section, a fibrous band may persist (including aponeurosis palm) and a constrictive localized stenosis on the median nerve realized.

DISCLOSURE

The author thanks Aspide Medical for lending freely the Surgicut device.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.hcl.2021.08.007.

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