Endoscopic Carpal Tunnel Release Without Invading the Tunnel: A New Transretinacular Technique

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Abstract: Established endoscopic carpal tunnel release (ECTR) techniques carry a not entirely eludible risk of iatrogenic complications, mainly because of incomplete view of the cutting blade and intraoperative pressure increase inside the carpal tunnel (CT). We describe a novel single-portal ECTR method, conceived to reduce these risks, by optimizing visual control and avoiding dilatation of the CT. After incising the well exposed proximal third of the transverse carpal liga-
ment (TCL), transection of the remainder is completed using a pediatric urethroscope. This small caliber instrument is moved in the plane of the TCL, without invading the tunnel, and provides detailed view of the TCL and any crossing anatomical structures at any given moment. We present the technique and the results of a retrospective case series of 33 patients with CT syndrome who underwent the procedure, after failing to respond to conservative treatment. Because of improved view and the avoidance of intraoperative pressure trauma to structures passing through the CT, the described approach may contribute to prevent iatrogenic complications and represent a valid improvement over conventional ECTR procedures.

Key Words: carpal tunnel syndrome, endoscopic carpal tunnel release, single-portal anterograde technique
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Carpal tunnel (CT) syndrome is the most common entrapment neuropathy and CT release ranges in many countries among the most frequently performed surgeries in orthopedics.

Open carpal tunnel release (OCTR) is a standard procedure with proven efficacy. The approach requires, however, a mid-palmar incision which in some cases may cause prolonged postoperative pain and/or wound-related problems such as scar tenderness and/or pillar pain.1,2 Several endoscopic carpal tunnel release techniques—ECTR (single-portal or double-portal)—have been introduced since 1989.3–6 resulting in shorter period with postoperative pain, faster recovery of grip strength,7 and earlier return to work.8–11 No significant differences are reported regarding the long-term results.12 The available techniques of ECTR carry, however, a higher risk for iatrogenic injury to neurovascular structures.13–15

An important risk factor concerns the cutting action to be carried out with the cutting blade/device partly out of view. Another critical aspect is the need to insert devices into the CT, thereby increasing the pressure on the median nerve, already damaged from chronic compression. Supraretinacular approaches, as proposed by some authors,16–19 would prevent such transient deficit of nerve function, but the use of relatively bulky devices may disrupt the subtle volar anatomy more than necessary and contribute to higher incidence of pillar pain.

To overcome these risks, we developed a direct transretinacular approach with optimized view and no need for displacing structures inside the tunnel or volar to the ligament. We present the technique and initial results.

ANATOMY

The carpal bones form the floor and walls of the CT. The transverse carpal ligament (TCL) attaches on the radial side to the scaphoid and to the trapezium, and on the ulnar side to the pisiform and to the hook of the hamate. This thick fibrous ligament forms the roof of the CT. From a surgical point of view, the distal end of the CT is reached when the fat surrounding the superficial palmar arch appears. The proximal end of the CT is not well defined anatomically. In fact, the antebrachial fascia blends distally into the TCL.

Through the CT pass the superficial and deep flexor tendons to the fingers, the flexor pollicis longus tendon and the median nerve that normally lies superficially in the radial quadrant of the tunnel, close to the covering TCL. The palmar cutaneous branch of the median nerve runs deep and parallel to the tendons of the flexor carpi radialis and the palmaris longus. Attention has to be paid to the variable course of the recurrent motor branch of the median nerve.20 It arises predominantly from the radial side of the median nerve and, thus, can generally be avoided by carrying out the release along the most ulnar aspect of the TCL. Other variants in the course of this branch may, however, put it at risk for injury if the transaction is performed without a detailed view of all TCL fibers that are about to be cut.

Indications/Contraindications

The indications for ECTR are the same as for OCTR: typical signs and symptoms as persistent tingling or numbness of the first 4 radial fingers, night pain, and weakness of the hand in spite of conservative treatment. Nerve conduction studies may be relevant to determine other forms of nerve compression proximal to the wrist.

Contraindications are carpal dislocations and fracture dislocations, malunion of the radius, previous surgery, stiffness of the wrist (extension should exceed 10 degrees to allow positioning and moving the instrument), tumors and synovitis in patients affected by rheumatoid arthritis or other forms of rheumatic diseases where synovectomy could be required.
When designing the procedure, emphasis was placed on finding a way to transect the TCL with maximum security and with least possible collateral damage, compared with pre-existent methods. To meet these goals, the principle was to accomplish the transection:

1. Under direct and unobstructed view of all structures in the path of the scalpel, without blind angles or blind spots.
2. In the plane of the ligament, without entering/dilating the CT or stretching the tissues volar to the ligament.

After analyzing the characteristics of different endoscopic instruments on the market, the choice fell on an off-the-shelf 11.5 Fr (3.8 mm) pediatric urethrotome (Richard Wolf GmbH, Knittlingen, Germany) (Fig. 1). The device is composed of an external oval stainless sleeve, a 2.7 mm diameter 0 degree rigid optical lens system and a tiny ovaloid disk shaped ceramic scalpel (diameter 2.4 mm) (Fig. 2) which slides on the optics rod. The spring mechanism in the handle retains the cutting blade inside the sleeve, 1 mm behind the shaft edge, so that no unwanted cuts are possible in this position. Because of the cutting edge of the stricture scalpel arranged in axial extension to the optics, the cutting process itself takes place under permanent optical control. The actuation of the stricture scalpel through the working element enables always controlled cutting with submillimetric precision. The optics is connected to the video camera. Continuous irrigation with physiological saline through the instrument sleeve guarantees clear view throughout the whole procedure.

The declared intended use of the device is cold cutting of tissues in an endoscopic setting, for example, of urethral strictures in small children. However, beyond its official destination in urologic surgery, the device’s technical characteristics make it well suited for incising connective tissue in narrow compartments in other body regions, with high precision and minimal invasiveness, under best possible visual control. It allows to get around some shortcomings of established ECTR methods, which convinced the institutional ethics review board to grant its off label use in ECTR procedures.

The procedure is performed in wide area local anesthesia and without tourniquet (WALANT). As with other CTR procedures, the patient is placed in a supine position with the arm abducted 90 degrees on a hand table. After disinfecting and draping the hand and underarm, the direction of the intended section of the TCL is lined out with a sterile marker pen, from the wrist to the fourth ray.
While keeping the transverse fibers under slight tension, the scalpel is carefully deployed with a small forward excursion of 1 to 2 mm in order to sever the stretched fibers (Fig. 9A) and then retracted again. Since the scalpel’s edge is smaller than the thickness of the ligament, these cutting movements are repeated 2 to 3 times, stepwise from volar to dorsal (Fig. 9B) until reaching the tunnel and obtaining a shallow cut through the whole thickness of the TCL.

Thereafter, the device is advanced again to stretch the cut edge and start dividing the next bundle of fibers, again stepwise, from volar to dorsal (Fig. 9C). It is important to constantly keep track of the alignment of the instrument with the fourth ray and check the direction of the cut to avoid deviating in a radial or ulnar direction.

After dividing the most distal strands of the TCL (Fig. 9D) and reaching the fat pad, the instrument is slowly retracted and the divided ligament is checked again for any remaining transverse fibers (Fig. 9E). The endoscopic sequence of the procedure is shown in the video (Supplemental Digital Content 1, http://links.lww.com/BTH/A132).

Eventually, the endoscope is removed and the antebrachial fascia is incised longitudinally for ∼1 cm in proximal direction under direct vision, using tenotomy scissors and the V-shaped director as a guide. After wound closure, a fluffy bandage is applied. The patients can move digits and wrist immediately. Heavy works and sport activities should be avoided for 3 to 4 weeks.

**Expected Outcomes**

Apart from shorter recovery, advocated for ECTR over OCTR procedures, complications of prevailing ECTR methods decrease with this new approach, thanks to better view and to the advancement of the endoscope in the plane of the TCL, thus avoiding pressure spikes inside the CT, caused by devices being pushed into it.

**Complications**

Possible complications include, first of all, accidental injury to the recurrent motor branch of the median nerve, to the superficial palmar arch or to the palmar cutaneous branch of the median nerve. These complications are described for both open and other endoscopic CTR procedures. The new approach should contribute in reducing the incidence of such untoward events, thanks to the superior view of the retinacular fibers and the cutting blade.

**MATERIALS AND METHODS**

Thirty-three patients with clinical and neurophysiological evidence of CTS underwent endoscopic release of the TCL with the new technique. Only patients, who explicitly chose to undergo this procedure, instead of open surgery, were included, if symptoms had failed to improve with 6 months of conservative treatment. All signed an informed consent, after having been comprehensively informed about the method and its novel character.
The series comprised 7 male and 26 female patients with a mean age of 60.5 years (range: 33 to 90 y). Two patients, both females, had a history of OCTR on the contralateral wrist in the past.

All participants underwent our department’s routine assessment for CTR candidates. After clinical and neurological evaluation, including EMG, the patients compiled a Boston CTS questionnaire (BCTQ) before and at the first postoperative control 2 weeks after surgery. Medium-term follow-up evaluation (pinch and grip strength, 2-point discrimination) was performed at 6 months. The procedures were carried out by 3 different surgeons.

RESULTS

Mean duration of the complete procedure, from incision to closure of the wound, was 22.7 minutes. The endocutting phase alone averaged 6.3 minutes (Table 1).

As expected, the procedure became steadily less time-consuming with growing number of performed surgeries. Overall, the learning curve appeared to be relatively short. No conversion to open surgery was required. No complications were encountered during or after the procedure, in particular no nerve related injuries or transient dysfunctions (neurapraxia).

All patients reported rapid recovery and return to daily activity within a few days. Pain subsided in all patients within the first days after surgery.

Those of them who had undergone OCTR in the past on the contralateral hand, expressed absolute preference for the new ECTR method.

The BCTQ score showed consistent improvement with the symptom severity score dropping from 2.79 ± 0.26, preoperatively, to 1.17 ± 0.11, 2 weeks after surgery, and the functional status score from 1.83 ± 0.20 to 1.38 ± 0.20. This latter figure (functional status score after 2 wk) has been negatively biased by the recommendation not to carry grocery bags during the first 2 weeks after surgery, resulting in a higher score.

At 6 months, all patients but one had recovered full sensibility and grip strength. Only the oldest patient, preoperatively presenting marked atrophy of the thenar muscles and reduced sensibility in the innervation area of the median nerve after longstanding compression symptoms, did not experience measurable improvement of grip strength or sensory function, but only disappearance of pain and discomfort at 2 weeks from surgery.

DISCUSSION

Endoscopic release techniques have originally been ideated to reduce recovery time and overcome wound-related morbidity.

| Duration (Minutes) | Phase I: Incision and Initial Open Section of Proximal TCL | Phase II: Endoscopic Section of Distal TCL | Phase III: Proximal Split of Antebrachial Fascia and Wound Closure | Total Time |
|-------------------|----------------------------------------------------------|------------------------------------------|-----------------------------------------------------------|-----------|
| Average           | 11.4                                                     | 6.3                                      | 4.2                                                       | 22.7      |
| Minimum           | 7, 0                                                     | 4.0                                      | 2.0                                                       | 13.0      |
| Maximum           | 20, 0                                                    | 9.0                                      | 8.0                                                       | 33.0      |

TCL indicates transverse carpal ligament.
The mean cross-section area of the CT has been measured to $134.9 \pm 23.6 \text{ mm}^2$.\textsuperscript{24} Consequently, introducing dilators and sheaths/devices of up to 7 mm in diameter with a displacing area of 30 to 40 mm$^2$ will encroach significantly on the structures passing through the CT by reducing the available space by 18% to 32%. Given the inextensible rigid structure of the CT, this inevitably leads to a critical increase of the mechanical hydrostatic intratunnel pressure.\textsuperscript{26,27} Any incidental out-of-angle movement of the instruments during these maneuvers may cause additional pressure. In contrast, established ECTR methods, our new approach did occur after OCTR. However, most ECTR methods employ a subretinacular approach which requires dilatation of the CT to accommodate the optical blade or sheaths used as guide for optical lens and scalpel (Fig. 10).\textsuperscript{3–5} The volume displaced by these devices inside the narrow and unyielding CT leads to additional pressure to the median nerve, already suffering from chronic compression, and may cause neurapraxia.

In cadaveric studies, the mean cross-section area of the CT was found to be $183.5 \pm 30.1 \text{ mm}^2$.\textsuperscript{25} Consequently, introducing dilators and sheaths/devices of up to 7 mm in diameter with a displacing area of 30 to 40 mm$^2$ will encroach significantly on the structures passing through the CT by reducing the available space by 18% to 32%. Given the inextensible rigid structure of the CT, this inevitably leads to critical increase of the mechanical and hydrostatic intratunnel pressure.\textsuperscript{26,27} Any incidental out-of-angle movement of the instruments during these maneuvers may cause additional pressure. Since CTS is a compression neuropathy, any increase in direct pressure on the already damaged median nerve may add to the injury, even if the rise in pressure is of short duration. In fact, neurapraxia of the median nerve following surgery may be an annoying complication after OCTR. However, most ECTR methods employ a subretinacular approach which requires dilatation of the CT to accommodate the optical blade or sheaths used as guide for optical lens and scalpel (Fig. 10).\textsuperscript{3–5} The volume displaced by these devices inside the narrow and unyielding CT leads to additional pressure to the median nerve, already suffering from chronic compression, and may cause neurapraxia.

In our experience, the procedure can readily be performed in high volume local anesthesia (WALANT). The procedure is almost bloodless despite not employing a tourniquet. Any minimal oozing of blood is cleared by the irrigating saline. Moreover, requirement for dissection and disruption on the volar surface of the TCL is minimal. The superior view of even finest anatomical structures allows to preserve muscular fibers and tissue layers that are not intrinsic part of the TCL on its volar surface. Initial observations in this limited series indicate reduced occurrence of pillar pain.

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handled with care according to instructions, even its most delicate part, the ceramic scalpel, can be reused in many procedures. This limits the costs of the procedure and compares positively against ECTR methods requiring expensive disposable parts like, for example, blade assemblies, etc.

In this observation study on a limited number of cases, after a short learning phase, the time required for the surgery showed to be comparable to other ECTR procedures. Technically, the procedure does not present particular difficulties, but a couple of details should, however, be paid attention to:
1. The skin incision should not be too short in order to guarantee the outflow of the irrigating fluid which is a prerequisite for clear vision.
2. Any significant out-of-angle deviation from the track toward the fourth ray will result in an oblique, and therefore longer track through the TCL, making the procedure slightly more awkward. Therefore, the direction of the cut should be checked regularly during the procedure.

The results in this first limited series of patients point toward confirming our expectations of obtaining the desired results, in particular a very swift recovery, with a procedure designed to be less traumatic and technically more accurate than any other ECTR procedure.

Further prospective controlled comparative studies with large cohorts are required to analyze in detail the short-term and long-term results.

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