

# Current Approaches for Carpal Tunnel Syndrome

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With advancement in biomechanical and biological research on idiopathic carpal tunnel syndrome, the insight on the pathophysiology of carpal tunnel syndrome has gained much clinical relevance. Open carpal tunnel release is still a gold standard procedure for carpal tunnel syndrome, which has evolved into mini-open procedure with development of new devices. Endoscopic carpal tunnel release has become popular in recent practice of hand surgery with an advantage of early recovery of hand function with minimal morbidity. However, endoscopic carpal tunnel release has its own limitation such as long learning curve with obvious surgical risk reported in the literature. In this review article, various treatment protocols for idiopathic carpal tunnel syndrome are presented with special highlight on endoscopic carpal tunnel release, which is gaining popularity in current practice.

**Keywords:** *Carpal tunnel syndrome, Open, Endoscopic, Release*

Carpal tunnel syndrome (CTS), the most common form of entrapment neuropathy in upper extremity, is estimated to occur in 3.8% of the general population. On the basis of clinical examinations and nerve conduction studies, it has been approximated that one in every five subjects who complain of symptoms such as pain, numbness, and a tingling sensation in the hands could have CTS.<sup>1)</sup>

According to the biomechanical and histological findings, the most characteristic histological finding is noninflammatory fibrosis and thickening of the subsynovial connective tissue. The hypothesis says surgical trauma to the synovium and the flexor tendons within the carpal tunnel associated with aging process or repetitive/forceful movement could lead to degeneration, thus as the volume of the carpal tunnel contents increases, median nerve within the tunnel is compressed and eventually resulted in CTS.

## CONSERVATIVE TREATMENT

When the pathophysiology of idiopathic CTS remained unclear, definitive treatment strategies have not been established. However, in recent practice, treatment should be selected considering the various factors, such as the stage of the disease, the severity of the symptoms, or the patient's preference. Splinting, local injection of corticosteroids into the carpal tunnel, and oral corticosteroid treatment have proven effective in some cases.<sup>2)</sup>

The rationale for wrist splint is based on observations that CTS symptoms improve with rest and aggravate with activity. Subsequent research has suggested that the therapeutic effect of wrist splinting arises from minimizing carpal tunnel pressure.<sup>3)</sup>

Corticosteroid treatment is effective in reducing inflammation and edema of synovium and tendons, it also has harmful effect on tenocyte function by reducing collagen and proteoglycan synthesis. This eventually reduces the mechanical strength of the tendon and leading to further degeneration.<sup>4)</sup> The effect of corticosteroids or local anesthetic agents on the peripheral nerve fibers or epineurium cells reported traumatic epineurial injury, axonal degeneration and intrafascial syrinx created by hydrostatic pressure.<sup>5)</sup> Further research is required to clarify the appropriate injection method and the optimum preparation,

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dose, and volume of corticosteroid.<sup>6)</sup>

**SURGICAL TREATMENT**

**Open Carpal Tunnel Release**

When conservative treatment fails, surgical treatment is considered. Despite the equivocal nature of CTS etiology, simple decompression of the median nerve by division of the transverse carpal ligament (TCL) is the treatment of choice and is considered to yield excellent results in 75% of the patients.<sup>7)</sup>

In the recent literature, surgical treatment has been reported to be more effective than splinting<sup>7)</sup> and other conservative treatment.<sup>8)</sup> Carpal tunnel release (CTR) with TCL division is accepted as the most reliable procedure for relieving symptoms. The TCL can be divided by various surgical techniques, including conventional open carpal tunnel release (OCTR), mini-OCTR, and endoscopic carpal tunnel release (ECTR). OCTR is generally accepted method,<sup>9)</sup> and reported high success rate with minimal

complication, although in worst scenario, some wound-related symptoms may persist for 2 years postoperatively.<sup>10)</sup> This surgery is indicated and feasible for CTS with any type of pathology, such as CTS due to any space occupying lesion, deformity or even in revision surgeries.

**Endoscopic Carpal Tunnel Release**

ECTR has gained popularity since their introduction two decades ago as single portal surgery by Okutsu et al.<sup>11)</sup> and two portal technique by Chow.<sup>12)</sup> Okutsu et al.<sup>13)</sup> developed their procedure with special tube like instrument to visualize whole TCL and it was transected under endoscopic assistance. At first, visualizing the dorsal aspect of the TCL by using endoscopy seemed highly innovative, attractive approach (Table 1, Fig. 1).<sup>14)</sup>

*Authors' preferred technique: anatomy principle based ECTR procedure*

1. Local anesthetics for instant feedback from the patient during surgery: We use Ropivacaine 7.5 mg/mL, 10 mL

**Table 1.** Reported Complications Related to First-Time ECTR

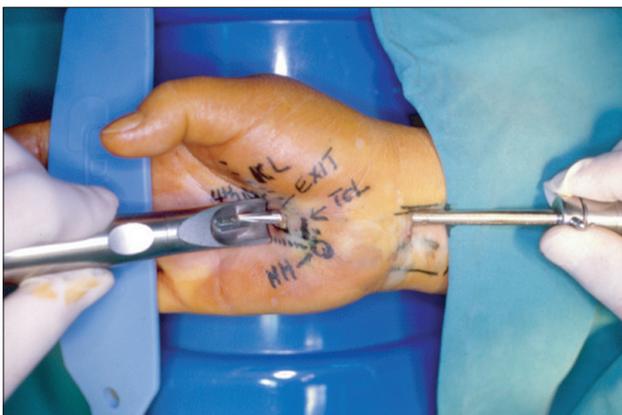
Complications	Trans-bursal	Extra-bursal	Total
Incomplete release	59	124	183
SPA injury	0	7	7
Ulnar nerve injury	1	0	1
Median nerve injury	0	2	2
Complication rate (%)	48	33	36

**Table 2.** Principles to Prevent Complications during ECTR

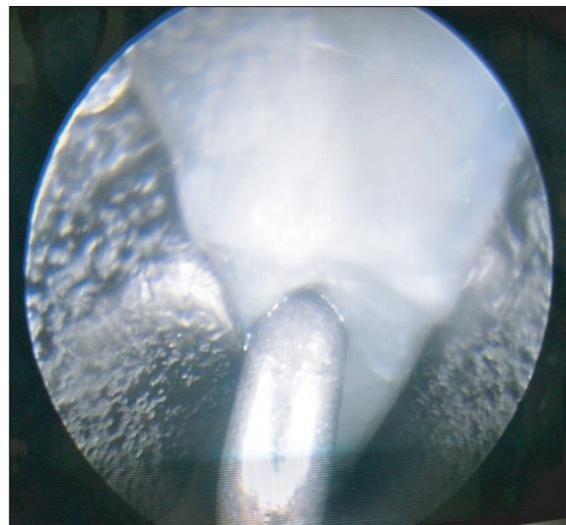
Topographic anatomy of entry and exit portals
Manipulation of instrument outside of tendon sheath
Clear space between TCL & cannula
Conversion to open in case of pain and difficulty

ECTR: endoscopic carpal tunnel release, TCL: transverse carpal ligament.

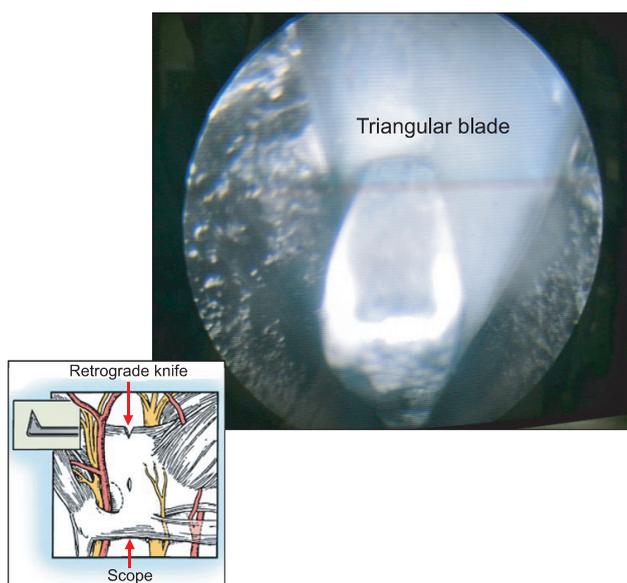
ECTR: endoscopic carpal tunnel release, SPA: superficial palmar arch. Reprint from Makowiec et al.<sup>14)</sup> with permission from Elsevier.



**Fig. 1.** Introducing the cannula to the exit portal. HH: hook of hamate, KL: Kaplan line, TCL: transverse carpal ligament.



**Fig. 2.** Undersurface of transverse carpal ligament with washboard appearance.



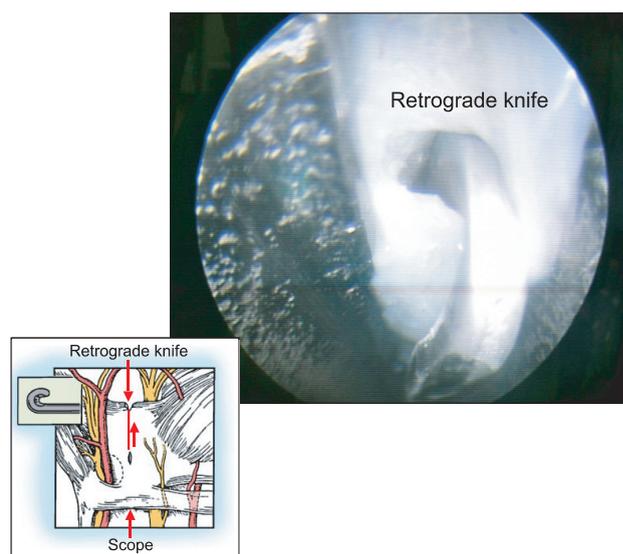
**Fig. 3.** Triangular blade cutting the middle of the transverse carpal ligament in retrograde fashion.

in total: 4 mL was administered in the proximal direction under the subcutaneous fascia, 2 mL subcutaneously in the distal wrist crease, and 4 mL subcutaneously in the palm.<sup>15)</sup>

2. Robust anatomic land marks to avoid potential damage of normal structure: A line is drawn for the planned incision that is a transverse incision on the distal wrist crease starting from the radial border of the palmaris longus (PL) extending ulnarly for 1.5 cm. If the PL is absent, a 1.5-cm incision centered on the line drawn from the ulnar border of the middle finger is used. The PL tendon is dissected and retracted radially to protect the palmar cutaneous branch of the median nerve exposing the deep fascia of the forearm (Table 2, Fig. 2).<sup>16)</sup>

3. Good endoscopic visualization and tapping the TCL with probe: Blunt dissection is performed to the proximal edge of the TCL. An elevator is used to clean the undersurface of the ligament to provide a good view with the endoscope. By palpating palm and watching it with endoscopy or inserting a needle from the palm into the canal, 4 cm distal to the transverse wrist crease, the end of the TCL is marked (Fig. 3).

4. Transecting the TCL: The probe knife is used to make the first cut, distally to proximally. The distal border of the TCL should be saved at this stage. The scope is switched into proximally and retrograde knife is brought in and the second cut to release complete TCL (Fig. 4).



**Fig. 4.** Transection of the transverse carpal ligament by using a retrograde knife.

#### *Clinical results of ECTR*

ECTR, either by single or dual-portal technique, can yield almost same clinical results comparable with those of OCTR. Unless iatrogenic nerve injury is counted, ECTR provides good symptom resolution, less scar and pillar pain, providing better physical findings and electrophysiologic recovery.<sup>17-19)</sup>

#### *Comparison with OCTR*

ECTR is useful for achieving median nerve decompression, its effectiveness in comparison with the minimally invasive OCTR for restoring function of the affected hand early after treatment is still under debate. The grip strength temporarily decreases after ECTR because of postoperative pain over the incision site, which is the case after any CTR procedure. Because of the ambiguity in the definition of 'resuming daily activities,' the average time required to resume daily activities or work after ECTR could not be addressed and compared directly. However, by using limited skin incision for ECTR, we expect the intact subcutaneous fatty tissue and palmar fascia will help for decreasing postoperative pain.

The benefit of ECTR over OCTR is that by dividing the TCL from below, the overlying skin and muscle are preserved, potentially improving postoperative morbidity, facilitating an earlier return to work, and preserving grip strength. The rate of major nerve, vessel, or tendon injury was shown to be lower in ECTR group, at 0.19% compared with 0.49% for the OCTR group. Similarly, Boecksyns and Sorensen<sup>20)</sup> reported a rate of 0.3% for irreversible

**Table 3.** Advantages and Disadvantages of Endoscopic Carpal Tunnel Release

Advantage	Disadvantage
Less pain	Unable to see all computed tomography contents
Earlier mobility	Higher risk in the presence of aberrant motor branch
Bilateral easier	Higher skill/training requirement
Earlier return to work	Cost of endoscopic equipment
Minimal skin/retinacular scar	
Nerve not 'scarred'	
Reduced 'pillar' pain	

nerve damage in the ECTR group, and 0.2% for the CTR group.<sup>21)</sup>

On the other hand, CTR had more wound problems such as infection, hypertrophic scar, and scar tenderness. Thoma and colleagues demonstrated a benefit of ECTR with respect to scar tenderness. ECTR also provides a faster recovery to operated patients for the first 2 weeks, with faster relief of pain and faster improvement in functional abilities. But at 1 year, both open and endoscopic techniques seem to be equivalently efficient (Table 3).<sup>22,23)</sup>

### PEARLS AND PITFALLS TO AVOID COMPLICATION

Practicing ECTR could result in a few disastrous complications such as transection of the median nerve, flexor tendons, superficial palmar arch or even the ulnar nerve, mostly because of technical errors (Table 4).

These complications usually could be avoided by adhering some principles to the recommended procedure: (1) the TCL should not be cut if soft tissue obstructs surgical view; and (2) very low threshold to conversion to open procedure if the surgeon encounters any difficulty introducing the cannula or achieving proper working space and good visualization just as like any endoscopic surgery (Table 2). Careful physical examination and preoperative ultrasonography or magnetic resonance imaging may be useful to detect space-occupying lesion for CTS.

Anatomic variations should be always kept in mind considering ECTR. Reported prevalence of anatomic variations encountered in elective CTR was 31 anomalies in total out of 526 CTR (5.7%). These included aberrant

**Table 4.** Reported Complication after ECTR and OCTR

Complication	ECTR (708 surgeons)	OCTR (616 surgeons)
Median nerve injury	100	147
Palmar cut branch injury	17	117
Ulnar nerve injury	88	29
Digital nerve injury	77	54
Tendon injury	69	19
Superficial palmar arch injury	86	21
Ulnar artery injury	34	11

ECTR: endoscopic carpal tunnel release, OCTR: open carpal tunnel release. Modified from Palmer and Toivonen<sup>23)</sup> with permission from Elsevier.

muscle/tendon variation, anomalies of the median nerve or its palmar cutaneous or motor branches, and anomaly of the ulnar nerve crossing the carpal tunnel incision.<sup>24)</sup>

Another potential limitation of ECTR—namely is related to the cannula (diameter 5.5 mm in Chow's technique) within the limited space of carpal tunnel which has already preceding pathologies in. As stated earlier, the pressure in the carpal tunnel was measured 5–85 mmHg in idiopathic CTS, which is greater than non-symptomatic population measured 3–6 mmHg.<sup>25)</sup>

ECTR is advised not to attempt without clear understanding of the anatomy of the target space because potential complications are mostly related to the technical pitfalls and anatomic variations.

### CONCLUSIONS

The current concepts of CTS and the role of ECTR in current surgical procedures were reviewed. ECTR is a useful technique for achieving median nerve decompression. However, there is lack of evidence-based clinical data to support ECTR provides superior clinical results to OCTR in terms of early recovery of hand function. Principle-based ECTR procedure, however provides few complications with successful clinical outcome so far. New treatment strategies can be established for CTS of different pathologies based on these clinical experiences.

### CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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