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***Retrospective Study***

**Recurrent carpal tunnel syndrome: Evaluation and treatment of the possible causes**

Eroğlu A *et al*. Recurrent carpal tunnel syndrome

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**Abstract**

***AIM***

to investigate the causes of the recurrent carpal tunnel syndrome (CTS) and implemented surgical interventions.

***METHODs***

Four hundred and eighty-seven patients, who were diagnosed with CTS and underwent surgical intervention between October 2016 and September 2007, were evaluated in this retrospective study. The age, gender, physical evaluation findings, electrophysiological examination reports and implemented surgical treatment methods were analyzed.

***RESULTS***

Thirty-nine of the cases were operated due to the recurrent CTS. The further examination of the patients with recurrent CTS revealed that 10 cases had diabetic polyneuropathy, 3 cases hypothyroidism, 2 cases rheumatoid arthritis and 1 case systemic amyloidosis. Postoperative electromyography confirmed the neuropathy due to systemic diseases. The remaining 23 patients with recurrent CTS did not have any systemic disease and all of them had applied previously to another health center.

***CONCLUSION***

We concluded that the recurrence rates in CTS might be decreased with exploration and incision of the entire transverse ligament. Damage to the motor and sensory branches of the median nerve could be avoided with an incision on the ulnar side.

**Key words:** Carpal tunnel; Electromyography; Entrapment neuropathies; Median nerve; retrospective study

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**Core tip:** In this study, 23 cases of recurrent carpal tunnel syndrome did not have any systemic disease and all of them had undergone a surgical intervention in another center. The incision was made starting from the distal of the volar wrinkle, passed between the thenar and hypothenar region, 2-3 mm medially to thenar wrinkle and extended 2-3 cm to the lateral side of the third finger. In recurrent cases, an appropriate differential diagnosis, re-operation without delay to avoid the development of the interfacial fibrosis, implementation of a precise and careful surgical technique play an important role in the improvement of the surgical outcome.

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**INTRODUCTION**

Entrapment neuropathies are disorders of peripheral nerves characterized by pain, numbness or loss of function. The symptoms depend on the compression caused by the adjacent anatomical structures. Carpal tunnel syndrome (CTS) is the most common peripheral nerve entrapment neuropathy and CTS surgery is the most commonly performed operation in the hand area[1-4]. Surgical decompression was first performed by Amadio[5] in 1995 and by Learmonth[6] in 1933. Variety of surgical decompression techniques have been described over the years[7-9] (Table 1). The prevalence of CTS is 0.6%-3.4% in the general population[10,11]. It has a higher prevalence in certain occupational groups[12,13]. CTS is five times more common in women than men between the ages of 30-60 years and the involvement is usually bilateral[12]. The increase of the pressure within the carpal tunnel is the major factor known in the etiology. The increased pressure impairs the blood supply of the median nerve and causes nerve damage[14].

A specific etiological factor may not be detected in the majority of the patients with CTS. CTS is idiopathic in approx. 50% of the patients. Most patients are occupied in works requiring repetitive wrist motions[12,15,16]. Patients with congenital narrow carpal tunnel are more prone to CTS. Secondary causes include anatomical causes such as abnormalities in the bone structures; traumatic structural disorders such as occupational recurrent microtrauma; systemic diseases such as amyloidosis, diabetes, hypothyroidism, rheumatic diseases, and tumors[11,17]. The sense of prickling in the hand, radiating numbness in three fingers, pain in the hand, wrist and medial side of the arm may emerge in early stages of the disease. Weakness and atrophy in the thenar muscles, loss of hand skills and impairment in daily life activities are the major findings in advanced and chronic cases.

**MATERIALS and METHODS**

***Study objective***

Four hundred and eighty-seven patients, who had undergone surgical intervention due to the diagnosis of CTS between September 2007 and October 2016, were evaluated retrospectively. The age, gender, physical evaluation findings, electrophysiological examination reports of the patients and the implemented surgical treatment methods were recorded.

***Inclusion and exclusion criteria***

448 (91.9%) of all cases had primary CTS and the remaining 39 (8.1%) cases had recurrent CTS. 23 of the patients with recurrent CTS, who had complaints for at least 3 mo, had no additional neural pathology and had persistent conduction disorders in sensory and motor fibers observed in electromyography (EMG), were included in this study. 16 patients with recurrent CTS, who had systemic diseases such as diabetes mellitus and thyroid disorders were excluded.

***Operative procedures***

Hypoesthesia in the median nerve sensation area, loss of strength in the radial 3 fingers, thenar muscle atrophy, Tinnel and Phalen signs were investigated during the clinical examination. Preoperative wrist x-ray images were evaluated and preoperative and postoperative (1st and 6th months) EMG images were examined in each patient. All patients were operated by the same surgeon. Regarding the prophylaxis of the infection, a single dose of a parenteral antibiotic was administered before the intervention and continued with an oral antibiotic for the next 3 d. All patients were discharged on the same day. An elastic bandage was used for the first 24 h and the arm was positioned in 90° flexion. Postoperative wrist splinting was not used. Next day after the operation, dressings were changed and finger exercises were started. Stitches were removed on the 10th day and exercises with softball and hot water bath were initiated. The mean follow-up time was 8.6 mo (range: 7.2-13 mo).

***Surgical technique***

Open surgery with a standard incision, open surgery with mini-incision or closed surgery such as endoscopic surgery and retinaculotomy may be used in CTS. We preferred a 2-3-cm mini-incision so that the entire transverse ligament could be visualized (Figure 1).

Open surgery with mini-incision was performed under local anesthesia without a tourniquet (Figure 1a). The patients were positioned supine on the operating table. The arm was placed on the surgical table slightly elevated and a small silicone pad was placed under the wrist, while the arm was in 90 ° abduction. Our standard incision starts from the distal of the volar wrinkle, passes between the thenar and hypothenar region, 2-3 mm medial to the thenar wrinkle and extends 2-3 cm distally to the lateral side of the third finger (Figure 1b). Regarding the patients with recurrent CTS, we preferred an open surgery with a 1-1.5 cm mini-incision over the previous long incision scar in patients who had previously undergone open surgery. A similar incision was done just at the distal side of the previous incision scar in patients, who had a transverse incision over the volar wrinkle and again a similar incision was done between the previous incision lines in patients, who had previously undergone endoscopic surgery (Figure 1c). Following the local anesthetic infiltration into the incision line, a vertical skin and subcutaneous incision was carried out. The skin and subcutaneous tissues were sharply incised with a No 15 blade and a skin retractor was inserted. The sharp dissection was deepened. After passing through the subcutaneous fat and the granulation tissue, the palmar aponeurosis and transverse ligament were exposed. The skin retractor was re-positioned and the transverse ligament was fully visualized. The ligament was completely and cautiously incised on the ulnar side of the median nerve with a No. 15 scalpel. Subsequently, a dissector was used to check whether the decompression was sufficient or not on the proximal and distal sides (Figure 2). The hemostasis was achieved with a compression on the palm for a few minutes. The skin was sutured with 4/0 vicryl and the wound was closed with a sterile dressing. The strength of abductor pollicis brevis and other flexor muscles and sensation in the thenar region was controlled at the end-stage of the operation.

***Statistical analysis***

Due to small sub-group numbers and no comparison statistical analysis was not carried out.

**RESULTS**

***Patient demographics and characteristics***

Regarding the patients with recurrent CTS cases (*n =* 23), 15 were females (65.2%) and 8 were males (34.8%). The mean age was 46.5 years (range: 21–69 years). In 12 of these cases, the left hand (52.1%) and in 11 the right hand (47.9%) was affected. The closed technique was previously performed in 10 of the patients with recurrent CTS (43.4%) (uniportal endoscopic technique (*n =* 4), biportal endoscopic (*n =* 4) and retinaculotomy technique (*n =* 2) were used). Regarding the previous interventions, the open surgery was in 6 cases with recurrent CTS (26.1%) and transverse mini-incision was used in 7 cases with recurrent CTS (30.4%) (Figure 3).

***Preoperative examination findings***

Following the first operation, all patients continued to have one or more complaints, which included nocturnal pain, sensory loss, and pain increasing with activity over the median nerve distribution area. The patients with recurrent symptoms stated that they had still the same complaints they had in the preoperative period for an average of 3.2 mo (1-7 mo) after the previous surgery. The clinical findings of the physical examination were the following: Sensory impairment in 16 cases (69.5%), nocturnal pain (awaken from sleep) in 18 cases (78.2%), and loss of hand strength in 13 cases (56.5%). Tinel sign and Phalen test sign were positive in 16 (69.5%) and in 13 cases (56.5%) respectively. The thenar atrophy was detected in 14 cases (60.8%) (Figure 4).

***Preoperative EMG findings***

Preoperative EMG examinations of patients with recurrent CTS revealed low amplitudes of the action potentials (severe) (*n =* 4), conduction disorders (moderate) both in sensory and motor fibers (*n =* 13) and conduction disorders affecting only the sensory fibers (*n =* 6). 2 cases of severe EMG changes had denervation potentials in thenar muscles and severe damage in median nerve.

***Surgical results***

Patients were operated with open mini-incision technique. The mean duration of the operation was 12 min (10-15 min). None of the cases had any additional complications concerning the motor and sensory branch of the median nerve. Wound infection emerged in 2 cases and hematoma in 1 case. One patient, who developed hematoma was immediately re-operated and hematoma was evacuated. Two patients with wound site infection were treated with oral antibiotics. The mean duration of return to daily living was 21 d (range: 16-27 d).

***Postoperative EMG findings***

 In the EMG examination performed in 6th month after the operation showed irreversible axonal damage in median nerve in two patients (these patients had findings of denervation in thenar muscles in the preoperative EMG examination). An improvement of latency in motor and sensory fibers of the median nerve was reported in all other cases.

**Discussion**

Conservative methods should be considered primarily in the treatment of CTS, but surgical treatment should be preferred in cases, who are not responding to conservative treatments[16,18,19]. The goal of the surgical treatment is to release transverse carpal ligament (TCL) completely and to decompress the canal. Decompression of median nerve with complete dissection of the TCL leads to a clinical improvement in the vast majority of patients[16,19-21]. Several surgical methods have been described in the surgery of CTS, including open and closed techniques. Although there is not any significant difference between these surgical methods in respect of clinical and electrophysiological outcome, recurrence may be encountered due to the incomplete or insufficient release of the transverse ligament[19,21,22].

 The carpal tunnel decompression surgery with an open technique, which was first performed by Amadio[5] in 1995 and later described by Learmont[6] in 1933, is still preferred[23-25]. Although it has been reported that this technique provides satisfying results, there are also certain disadvantages such as pain over the incision site, sensitivity on the scar tissue, delayed return to daily activities and work[16]. Thus, alternative methods have been developed to avoid postoperative morbidity after open surgery[1]. Chow[26] and Agee *et al*[27] reported that with the widespread use of endoscopic methods, with the new developments in endoscopic instruments and, with more experienced surgeons, the postoperative morbidity is decreased, time to return to work after the surgery is shortened, and the scars are more cosmetic and painless. However, endoscopic techniques may also lead to high complication rates when performed without adequate knowledge of endoscopic anatomy and adequate experience[15,18,28].

 Evaluation of the entire carpal tunnel may not be possible during the endoscopic surgery and cutting the transverse ligament without adequate visualization may increase the risk of the median nerve injury[28]. Lee reported that the median nerve was injured in 2 cases in their series[29]. It is also possible that space-occupying lesions may be overlooked during the endoscopic surgery. Endoscopic surgery also requires a high level of surgical experience and special instrumentation and, cannot be implemented in cases of neurolysis or tenosynovectomy[30].

 With open mini-incision technique, the entire transverse ligament can be visualized and the median nerve and the canal may be fully investigated. All 23 patients with recurrent CTS, who were included in our study had been previously operated with different surgical techniques in different centers. We observed in all of these patients that the release of the transverse ligament was incomplete and the median nerve was still under compression. We resolved the inadequate decompression with a complete incision of the ligament (Figure 2). All cases stated that their nocturnal pain, which was awakening them from sleep, relieved on the first day after the operation. The carpal tunnel decompression with open surgery is considered as the gold standard in the treatment of CTS[1,18,21]. Although successful results have generally been reported with this method, certain disadvantages may be also encountered like weakness in the hand, sensitivity on the scar tissue, delayed return to daily activities and work[1,31]. Various complications including injury to the palmar cutaneous branch (PCB) of the median nerve, hypertrophic incision scar, reflex sympathetic dystrophy, and increased tension in flexor tendons have also been reported after open surgery[1]. In our cases, we did not encounter these abovementioned complications except wound infection and hematoma.

 PCB arises from the median nerve before the TCL. This branch provides the sensitive innervation of the thenar region of the hand and plays a major role in the planning of surgical incision in the carpal tunnel surgery. According to some authors, this sensory branch extends to the ulnar side[10]. For this reason, Franzini *et al*[32] preferred a 1-cm longitudinal incision proximal to the wrist flexor line. Abdullah *et al*[22] reported that PCB was arising from the radial side of the median nerve and is always located lateral to the palmaris longus (PL) tendon so that they were using a transverse incision at the medial side of the PL tendon. In our cases, we used a mini-incision starting from the distal side of the wrist flexor line and extended the incision 2-3 mm to the medial side of the thenar line. We exposed the entire transverse ligament, identified PCB and incised the transverse ligament on the medial side of the median nerve.

 Regarding the recurrence after the CTS surgery, the most common reason is the incomplete release of the distal part of the TCL[21]. A 2-3-cm open mini-incision enables the visualization of the distal part of the ligament. However, in this study, in patients with recurrent CTS, we extended the mini-incision about 1-1.5 cm due to the fibrotic scar tissue formation. The median nerve is divided into two main trunks (lateral and medial) at the distal end of the TCL. The branch, which provides motor innervation, originates from the lateral trunk. The several anatomic variations of this motor branch should be taken into consideration during the planning of the surgical incision[10]. According to Lanz classification, the variations of the motor branch include extra-ligamentous, subligamentous, and less commonly transligamentous localizations[33]. This branch originates rarely from the ulnar side of the median nerve and rarely gives recurrent motor branches[33]. We believe that the implementation of the closed techniques (*e.g.*, endoscopic methods) and the dissection of the transverse ligament without fully visualizing the median nerve may cause iatrogenic neural injuries depending on the anatomic variations of the median nerve. In addition, recurrence may be encountered also in the closed techniques due to the incomplete dissection of TCL and the inadequate decompression of the median nerve.

We used an open mini-incision technique in our cases and carried out a small incision to release median nerve and cut TCL, volar carpal ligament and deep palmar fascia. Shapiro[34] reported good results in 96% of patients with a technique named “carpal tunnel release with microsurgery”, which is performed by a mini-incision using special instruments (microscope and Easyloupe). Decompression of the transligamentous motor branch with this incision is also possible. However, the most common disadvantage of this incision is a large scar and loss of hand function[22]. One of the most frequently discussed issues is “Should the incision be longitudinal or transverse?”[35]. Authors, who prefer a longitudinal incision, suggest that PCB injuries may be avoided with this incision. However, according to the experience gained from the anatomic studies, PCB rarely extends to the medial side of the PL tendon[10]. Therefore, PCB can be preserved by an incision that does not extend to the lateral side of the PL tendon[35]. In our cases, we incised the transverse ligament from the ulnar side of the median nerve.

 The average time to return to the daily activities was longer after the open surgical method compared to the endoscopic and open mini-incision surgical methods[30]. This duration was 14-17 d after the closed technique and 28 d after the open surgery[24]. In our cases, the average time to return to the daily activities was 17 d (14-21 d). The comparison of the outcome in both groups does not show any significant difference between open and closed surgical methods. But 10%-15% of patients who had undergone endoscopic surgery encountered an inadequate relief in symptoms or an early onset of the recurrence[25]. Median, ulnar and digital nerve injuries have been reported in the literature for both open and closed technique[36]. In our cases, no additional neural damage was observed. In addition to the relatively simpler technique and being easier to learn, the lower cost of the surgical instruments used in open mini-incision surgery is another advantage in comparison to the endoscopic and retinaculotomy technique[37] Surgical experience, special instruments and appropriate assistance are required for endoscopic surgery and retinaculotomy methods. One of the major disadvantages of the closed technique is the increased injury risk of the ulnar-radial artery arch[26]. Other advantages of the open mini-incision surgical incision technique, which we used in our study, include the easy access to the proximal and the distal end of TCL, prevention of the damage to the superficial palmar arch, and preservation of the motor branch, that innervates *m. abductor pollicis brevis*.

 Our patients stated that nocturnal paresthesia relieved immediately in the next day after CTS surgery. If the pain is not immediately relieved after the surgery, an incomplete incision of TCL should be considered[10]. We believe that the preference of an open surgical technique with complete incision of the carpal transverse ligament will enable a complete decompression of the median nerve, and consequently a significant reduction in the recurrence and neuronal injury rates. In patients with recurrent CTS, an appropriate differential diagnosis, re-operation without delay to avoid development of interfacial fibrosis, implementation of a precise and careful surgical technique, and initiation of an appropriate exercise program in the postoperative period are the factors, which are contributing to the improvement of surgical outcome.

**ARTICLE HIGHLIGHTS**

***Research background***

The reasons for the recurring carpal tunnel have been researched since the 1990s. Studies have investigated fibrosis and surgical techniques. However This study demonstrates that the median nerve should be relieved by full incision the transverse ligament.

***Research motivation***

In the carpal tunnel surgery, the recurrence rate was increased following the widespread use of the endoscopic and the minimally invasive techniques. A satisfying surgical outcome cannot be achieved if the compression caused by the transverse ligament cannot be completely relieved. The development of the endoscopic and minimally invasive techniques and the proper training of the relevant surgeons will decrease the recurrence rates. The critical step in the carpal tunnel syndrome surgery is the complete incision of the transverse ligament on the median nerve and the relief of the compression. Independent of the selected surgical technique, the complete incision of the transverse ligament should be assured.

***Research objectives***

The main aim of the study is to perform the carpal tunnel surgeon without the need for a second operation with the appropriate surgical method. The re-operation of the patients with recurrence prolongs the hospitalization time with the consequential economic loss. Careful and appropriate surgery will prevent them. Appropriate surgical method will prevent surgeons from encountering medicolegal problems. Complete incision of the transverse ligament will reduce recurrence rates of Recurrence of carpal tunnel surgery.

***Research methods***

Four hundred and eighty-seven patients were evaluated retrospectively. The age, gender, physical evaluation findings, electrophysiological examination reports of the patients and the implemented surgical treatment methods were recorded in this research.

***Research results***

Fibrosis and surgical methods have been criticized in the literature. However, this manuscript emphasized that the importance of removing ligament integrity completely. If the complete incision of the transverse ligament is not assured with the endoscopic and minimally invasive methods, an open surgery technique must be implemented.

***Research conclusions***

The relief of the median nerve in carpal tunnel surgery occurs when the transverse ligament is completely incision. Recurrence rates decrease. Regardless of the surgical procedure, it should be ensured that the transverse ligament is completely incision. If minimally invasive methods are insufficient in nerve decompression, open surgery should be performed.

***Research perspectives***

Complete incision of the transverse ligament will reduce recurrence rates of recurrence of carpal tunnel surgery. This study demonstrates that the median nerve should be relieved by fully incision the transverse ligament. This manuscript emphasized that the importance of removing ligament integrity completely. A satisfying surgical outcome cannot be achieved if the compression caused by the transverse ligament cannot be completely relieved. The relief of the median nerve in carpal tunnel surgery occurs when the transverse ligament is completely incision. Recurrence rates decrease. If minimally invasive methods are insufficient in nerve decompression, open surgery should be performed.

**REFERENCES**

1 **Jimenez DF**, Gibbs SR, Clapper AT. Endoscopic treatment of carpal tunnel syndrome: a critical review. *J Neurosurg* 1998; **88**: 817-826 [PMID: 9576248 DOI: 10.3171/jns.1998.88.5.0817]

2 **Paget J.** Lectures on Surgical Pathology. Lindsay and Blakiston, 3rd ed. Philadelphia 1854: 173-179

3 **Tulipan JE**, Kim N, Abboudi J, Jones C, Liss F, Kirkpatrick W, Rivlin M, Wang ML, Matzon J, Ilyas AM. Open Carpal Tunnel Release Outcomes: Performed Wide Awake versus with Sedation. *J Hand Microsurg* 2017; **9**: 74-79 [PMID: 28867906 DOI: 10.1055/s-0037-1603200]

4 **Nazari G**, Shah N, MacDermid JC, Woodhouse L. The Impact of Sensory, Motor and Pain Impairments on Patient- Reported and Performance Based Function in Carpal Tunnel Syndrome. *Open Orthop J* 2017; **11**: 1258-1267 [PMID: 29290864 DOI: 10.2174/1874325001711011258]

5 **Amadio PC**. The first carpal tunnel release? *J Hand Surg Br* 1995; **20**: 40-41 [PMID: 7759932 DOI: 10.1016/S0266-7681(05)80013-0]

6 **Learmonth J**. The princible of decompression in treatment of certain diseases of peripheral nerves. *Surg Clin North Am* 1933; **13**: 905-913

7 **Love JG**. Median neuritis or carpal tunnel syndrome; diagnosis and treatment. *N C Med J* 1955; **16**: 463-469 [PMID: 13266163]

8 **Phalen GS**, Gardner WJ, La Londe AA. Neuropathy of the median nerve due to compression beneath the transverse carpal ligament. *J Bone Joint Surg Am* 1950; **32A**: 109-112 [PMID: 15401727 DOI: 10.2106/00004623-195032010-00011]

9 **Mirza MA**, King ET Jr. Newer techniques of carpal tunnel release. *Orthop Clin North Am* 1996; **27**: 355-371 [PMID: 8614584]

10 **Serarslan Y,** Melek İ, Duman T. Karpal Tunel Sendromu. *Pamukkale Tıp Dergisi* 2008; **1**: 45-49

11 **Kürklü M,** Türkkan S, Tüzün HY. Karpal tünel Sendromu ve Median Sinirin Diğer Tuzak Nöropatileri. *TOTBİD Dergisi* 2015; **14**: 566–571 [DOI: 10.14292/totbid.dergisi.2015.78]

12 **Papanicolaou GD**, McCabe SJ, Firrell J. The prevalence and characteristics of nerve compression symptoms in the general population. *J Hand Surg Am* 2001; **26**: 460-466 [PMID: 11418908 DOI: 10.1053/jhsu.2001.24972]

13 **Stevens JC**, Beard CM, O'Fallon WM, Kurland LT. Conditions associated with carpal tunnel syndrome. *Mayo Clin Proc* 1992; **67**: 541-548 [PMID: 1434881 DOI: 10.1016/S0025-6196(12)60461-3]

14 **Bland JD**. Carpal tunnel syndrome. *Curr Opin Neurol* 2005; **18**: 581-585 [PMID: 16155444 DOI: 10.1097/01.wco.0000173142.58068.5a]

15 **Urbaniak JR**, Desai SS. Complications of nonoperative and operative treatment of carpal tunnel syndrome. *Hand Clin* 1996; **12**: 325-335 [PMID: 8724584]

16 **Şavk O,** Turgut M, Çullu E, Akyol A, Alparslan B. Karpal Tünel Sendromunun cerrahi dekompresyonunda standart ve mini insizyon tekniklerinin karşılaştırılması. *ADÜ Tıp Fakültesi Dergisi* 2002; **3**: 9-13

17 **Kıbıcı K,** Köksal V. Mini Açk Teknikle Yapılan Karpal Tünel Cerrahisi ve Fonksiyonel Sonuçları. *Türk Nöroşirürji Dergisi* 2010; **20**: 7-14

18 **Zamborsky R**, Kokavec M, Simko L, Bohac M. Carpal Tunnel Syndrome: Symptoms, Causes and Treatment Options. Literature Reviev. *Ortop Traumatol Rehabil* 2017; **19**: 1-8 [PMID: 28436376 DOI: 10.5604/15093492.1232629]

19 **Vázquez-Alonso MF**, Abdala-Dergal C. [Principal causes for recurrent carpal tunnel syndrome]. *Acta Ortop Mex* 2016; **30**: 17-20 [PMID: 27627773]

20 **Szabo RM**, Steinberg DR. Nerve Entrapment Syndromes in the Wrist. *J Am Acad Orthop Surg* 1994; **2**: 115-123 [PMID: 10708999 DOI: 10.5435/00124635-199403000-00005]

21 **Dahlin LB**, Salö M, Thomsen N, Stütz N. Carpal tunnel syndrome and treatment of recurrent symptoms. *Scand J Plast Reconstr Surg Hand Surg* 2010; **44**: 4-11 [PMID: 20136467 DOI: 10.3109/02844310903528697]

22 **Abdullah AF**, Wolber PH, Ditto EW 3rd. Sequelae of carpal tunnel surgery: rationale for the design of a surgical approach. *Neurosurgery* 1995; **37**: 931-5; discussion 935-6 [PMID: 8559342 DOI: 10.1227/00006123-199511000-00012]

23 **Cellocco P**, Rossi C, El Boustany S, Di Tanna GL, Costanzo G. Minimally invasive carpal tunnel release. *Orthop Clin North Am* 2009; **40**: 441-448, vii [PMID: 19773048 DOI: 10.1016/j.ocl.2009.06.002]

24 **Atroshi I**, Johnsson R, Ornstein E. Endoscopic carpal tunnel release: prospective assessment of 255 consecutive cases. *J Hand Surg Br* 1997; **22**: 42-47 [PMID: 9061522 DOI: 10.1016/S0266-7681(97)80013-7]

25 **Hulsizer DL**, Staebler MP, Weiss AP, Akelman E. The results of revision carpal tunnel release following previous open versus endoscopic surgery. *J Hand Surg Am* 1998; **23**: 865-869 [PMID: 9763263 DOI: 10.1016/S0363-5023(98)80164-0]

26 **Chow JC.** Endoscopic release of the carpal ligament: a new technique for carpal tunnel syndrome. Arthroscopy 1989; 5: 19-24 [PMID: 2706047 DOI: 10.1016/0749-8063(89)90085-6]

27 **Agee JM,** McCarroll HR Jr, Tortosa RD, Berry DA, Szabo RM, Peimer CA. Endoscopic release of the carpal tunnel: a randomized prospective multicenter study. J Hand Surg Am 1992; 17: 987-995 [PMID: 1430964 DOI: 10.1016/S0363-5023(09)91044-9]

28 **Chen AC**, Wu MH, Cheng CY, Chan YS. Outcomes and Satisfaction with Endoscopic Carpal Tunnel Releases and the Predictors - A Retrospective Cohort Study. *Open Orthop J* 2016; **10**: 757-764 [PMID: 28217200 DOI: 10.2174/1874325001610010757]

29 **Lee WP**, Strickland JW. Safe carpal tunnel release via a limited palmar incision. *Plast Reconstr Surg* 1998; **101**: 418-24; discussion 425-6 [PMID: 9462775 DOI: 10.1097/00006534-199802000-00025]

30 **Atroshi I**, Johnsson R, Ornstein E. Patient satisfaction and return to work after endoscopic carpal tunnel surgery. *J Hand Surg Am* 1998; **23**: 58-65 [PMID: 9523956 DOI: 10.1016/S0363-5023(98)80090-7]

31 **Bradley MP**, Hayes EP, Weiss AP, Akelman E. A prospective study of outcome following mini-open carpal tunnel release. *Hand Surg* 2003; **8**: 59-63 [PMID: 12923936 DOI: 10.1142/S021881040300187X]

32 **Franzini A**, Broggi G, Servello D, Dones I, Pluchino MG. Transillumination in minimally invasive surgery for carpal tunnel release. Technical note. *J Neurosurg* 1996; **85**: 1184-1186 [PMID: 8929518 DOI: 10.3171/jns.1996.85.6.1184]

33 **Lanz U**. Anatomical variations of the median nerve in the carpal tunnel. *J Hand Surg Am* 1977; **2**: 44-53 [PMID: 839054 DOI: 10.1016/S0363-5023(77)80009-9]

34 **Shapiro S**. Microsurgical carpal tunnel release. *Neurosurgery* 1995; **37**: 66-70 [PMID: 8587693 DOI: 10.1097/00006123-199507000-00010]

35 **Kulick RG**. Carpal tunnel syndrome. *Orthop Clin North Am* 1996; **27**: 345-354 [PMID: 8614583]

36 **Bozentka DJ**, Osterman AL. Complications of endoscopic carpal tunnel release. *Hand Clin* 1995; **11**: 91-95 [PMID: 7751336]

37 **Lee H**, Jackson TA. Carpal tunnel release through a limited skin incision under direct visualization using a new instrument, the carposcope. *Plast Reconstr Surg* 1996; **98**: 313-9; discussion 320 [PMID: 8764720 DOI: 10.1097/00006534-199608000-00016]

38 **Marie P,** Foix C. Atrophie isolée de l'éminence thenar d'origine névritique: rôle du ligament annulaire antérieur du carpe dans la pathogénie de la lesion. *Rev Neurol* 1913; **26**: 647-649

39 **Cannon BW**, Love JG. Tardy median palsy; median neuritis; median thenar neuritis amenable to surgery. *Surgery* 1946; **20**: 210-216 [PMID: 20994804]

40 **Biyani A**, Downes EM. An open twin incision technique of carpal tunnel decompression with reduced incidence of scar tenderness. *J Hand Surg Br* 1993; **18**: 331-334 [PMID: 8345260 DOI: 10.1016/0266-7681(93)90055-K]

41 **Bromley GS**. Minimal-incision open carpal tunnel decompression. *J Hand Surg Am* 1994; **19**: 119-120 [PMID: 8169355 DOI: 10.1016/0363-5023(94)90234-8]

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**Table 1 Milestones of the carpal tunnel syndrome decompression surgery**

|  |  |  |
| --- | --- | --- |
| **References** | **Year** | **Accomplishment** |
| Marie *et al*[38] | 1913 | Defined median nerve compression |
| Amadio[5] | 1924 | Median nerve decompression by transecting the transverse carpal ligament |
| Learmonth[6] | 1933 | Median nerve decompression by transecting the transverse carpal ligament |
| Cannon *et al*[39] | 1946 | Reported good results with the release of transverse carpal ligament with median nerve compression |
| Phalen *et al*[8] | 1950 | Started using standard open approach  |
| Chow[26] | 1989 | Described dual portal endoscopic decompression technique |
| Agee *et al*[27] | 1992 | Single proximal portal endoscopic decompression technique  |
| Biyani *et al*[40] | 1993 | Described mini-open double-incision technique  |
| Bromley[41] | 1994 | Single distal mini-open technique  |

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**Figure 1 Mini open incision method.** A: Local anesthetic application to the incision line; b: The standard incision starts from the distal volar wrinkle, passes between the thenar and hypothenar region 2-3 mm medially to thenar wrinkle and extends 2-3 cm distally to lateral side of the third finger; c: Placement of the skin retractor after sharp dissection.



**Figure 2 Extended mini open incision technique in a patient previously operated with uniportal endoscopic method.** a: Endoscopic portal scar over the distal wrist wrinkle (red arrow); b: Incomplete incision of the transverse carpal ligament and compression on median nerve (black arrow); c: The incision is completed and the median nerve is fully decompressed.

**Figure 3 Ten recurrent cases (43.4%) were previously operated with closed technique (uniportal endoscopic technique in 4, biportal endoscopic technique in 4 and retinaculotomy technique in 2 cases).** Six recurrent cases (26%) were previously operated with open surgical method and 7 recurrent cases (30.4%) were previously operated with transverse mini incision.

**Figure 4 There were thenar atrophy in 14 cases (60.8%).** Phalen test was positive in 13 cases (56.5%).Tinel sign was found in 16 cases (69.5%). Loss of hand strength in 13 cases (56.5%), nocturnal pain in 18 cases (78.2%) and sensory impairment was detected in 16 cases (69.5%).