5 Carpal Tunnel Release with Two Small Cross-Aligned Incisions

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Carpal Tunnel Syndrome: Demographics and Historical Data

Median nerve compression neuropathy at the wrist level, widely known as carpal tunnel syndrome (CTS), is the most common peripheral nerve entrapment syndrome affecting 3.8% in the general population, mainly middle-aged females either as an acute or chronic CTS [1]. Acute CTS is relatively uncommon, caused by any acute injury increasing the pressure into the carpal tunnel. Chronic CTS is the commonest type, associated with a variety of etiologies ranging from local (such as tumors or anatomic abnormalities) to systematic (hypothyreoidism, sarcoidosis, diabetes mellitus) and several occupations that rising the pressure within the carpal tunnel [2].

The earliest symptoms of the CTS initially appear as sensory function deficit with paresthesia, numbness and pain variably involving the thumb, the index, the median and the radial half of the ring finger [2]. Patients are commonly complaining for nocturnal awakening pain and numbness in the early stage, followed by muscular weakness and loss of grip and pinch strength in the more advanced stage. In more severe and neglected cases, the patients may develop thenar muscles atrophy due to involvement of the motor brunch of the median nerve. Pain radiating to the forearm and the shoulder is often mentioned by the patient without clinical evidence of apparent neuropathy or compression proximal to the wrist.

There are several clinical tests to assist to the diagnosis of the CTS. Tinel's and Phalen's sign, are the most common in use [2–4]. The diagnosis is confirmed with the use of nerve conduction and complete electro-physiology studies, which in a number of patients may not turn positive.

Historically, the median nerve compression neuropathy at the wrist level (carpal tunnel syndrome-CTS) was described in 1854 by Sir James Paget, in a patient suffering from pain and impaired sensation of the hand after a distal radius fracture [5]. Almost 30 years later in 1880 Putnam presented a series of 37 patients with sensibility disturbances in the median nerve distribution area of the hand [6]. The pathology of CTS and the role of the transverse carpal ligament (TCL) on the median nerve compression were further elucidated in 1913 by Marie and Foix [7]. Twenty years later, in 1933, Learmonth described the first TCL release as a

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surgical treatment to medial nerve entrapment neuropathy at the wrist [8]. Since then several techniques have been reported in the literature each one of them expressing both benefits and pitfalls.

Anatomy of the Carpal Tunnel and the Variations of the Median Nerve

The carpal tunnel is dorsally defined by the proximal carpal row (floor), the hook of the hamate and the pisiform at the ulnar side, the scaphoid tubercle and the trapezium on the radial side and the TCL at the volar side.

Ten anatomical structures pass through the carpal tunnel, including the nine flexor tendons of the fingers and the median nerve. The median nerve after exiting the carpal tunnel divides into the first and second common digital nerves, and the digital nerve for the radial side of the index which supply sensory innervation to lateral palm and through the digital cutaneous branches innervates the radial 3 1/2 digits (palmar) and can also supply the index, long, and ring fingers dorsally. The recurrent motor branch of the median nerve innervates the 1st and 2nd lumbricals, the opponens pollicis, the abductor pollicis brevis and the flexor pollicis brevis muscle. The take off of this recurrent motor branch presents several anatomical variations classified into three groups, by Lanz in 1977 [9]. The first variation occurs in the majority of cases (49%) with the origin of the recurrent motor branch from the median nerve radially, and distal to the transverse carpal ligament. In the second most common variation (30%) the branch is taking off within the carpal tunnel, while in the third less common type (20%) the recurrent motor brunch arises from the median nerve and tenets the transverse carpal ligament. Two more, rare variations have been also described, in the first of them the recurrent motor branch takes off from the ulnar and anterior area, bridging the median nerve as it approaches the thinner musculature [10], while in the other one, occurring in 9% of cases, the motor branch may have a course superficial to the transverse carpal ligament [11]. The identification of these variations is essential in order to avoid iatrogenic injury of the recurrent motor branch during the carpal tunnel release.

Surgical Techniques and Complains or Complications Following CTS Surgery

Since 1933, when Learmonth described the first surgical approach for the TCL release as a treatment to CTS [8], several surgical techniques have been described ranging from extended open to minimally invasive operations, to endoscopic techniques.

There are three basic techniques for treating CTS, Open Carpal Tunnel Release (OCTR), Minimal Incision Carpal Tunnel Release (MICTR), including mini distal incision release and double mini incision release and Endoscopic Carpal Tunnel Release (ECTR).

Open carpal tunnel release provides direct visualization of all anatomical structures, preventing iatrogenic complications such as palmar arch artery or median nerve injury. Although it is associated with a low intra-operative complication rate, a number of patients may be dissatisfied after open carpal tunnel release due to painful scar, loss of grip strength, reflex sympathetic dystrophy, bow stringing of flexor tendons and pillar pain [12, 13]. Pillar pain is the term used to describe pain and tenderness in the thenar or hypothenar area. The etiology is unclear but in some cases it is associated with disruption of the carpal arch structures during surgery, soft tissue edema, injury to the cutaneous branches of the palm or relaxation of the muscles of opposition and pinch following sectioning of TCL [12].

In order to avoid certain postoperative complications related to the OCTR, alternative minimally invasive techniques have been introduced, including a limited transverse incision of ≤2 cm technique at the same area as open release. Atik et al in 2001 [14] described a modification of the mini open technique but no difference in the long term results on patients undergoing open or mini open CTS release were demonstrated.

ECTR was first performed by Okutsu in 1987 [15] and since then several different endoscopic approaches were described. The most widely used are Agee's single-portal technique [16] and Chow's two-portal technique [17]. Although endoscopic techniques seemed promising there were no differences between them and the open techniques on the long term results, with the exception of the more aesthetically appealing scar, the reduced scar tenderness and increase in pinch grip and pinch strength at 12 weeks follow up.

The Mini Open Surgical Technique with Two Small Cross Aligned Incisions (TSCAI)

The patient is placed supine on the surgical table with an addition of arm support extension. Very few surgical instruments are needed to perform this surgical procedure (Fig. 5.1). A tourniquet is applied at the arm and the surgical field of the forearm and the hand is prepared with 4% chlorexidine scrub and solution. The local anaesthesia is applied prior to the tourniquet inflation in order to avoid excess of tourniquet time and also to achieve diffusion of its components during the bloodletting. A mixture of local anaesthetics including 2% lidocaine, 7.5% ropivacaine and normal saline 0.9% in a 5-3-2 ratio is prepared and injected slowly under the skin proximal to the palmar wrist creases (Fig. 5.2). Following this the needle is re-entered through the previously anaesthetised skin, now directed distally under the palmar skin between the thenar and hypothenar in the axis of the Taleisnik's line towards the distal surgical incision.

Fig. 5.1 The basic instruments that are needed to successfully release the TCL with the two small cross aligned incisions technique

The incisions are marked on the skin using the distal crease of the wrist as the proximal anatomical landmark and the intersection between Kaplan's line and Taleisnik's line as demonstrated as the distal landmark (Fig. 5.3). Then, the tourniquet is inflated, usually at 250 mmHg, and a 1.5 cm transverse skin incision is performed at the distal crease of the wrist, ulnarly to the flexor carpi radialis (FCR) tendon (Fig. 5.4a). The superficial dissection begins proximally to identify and incise the superficial forearm fascia. The Palmaris Longus (PL) tendon is identified when present and protected and then the deep forearm fascia is incised in a pointed way with the knife tip, with particular care to prevent damage to the median nerve running underneath. It is worth mentioning that in case of accidental damage of the PL tendon, there will not be any real functional deficit, as there is no proximal retraction due to its junction with the distal forearm fascia. Careful dissection is required to avoid injury of the palmar cutaneous branch of the median nerve. Through the small longitudinal incision of the fascia, a thin grooved knife guide with a blunt tip is inserted from distal to proximal direction. Then the distal forearm fascia is incised for approximately 2 cm with a #15 scalpel blade sliding within the guide from distal to proximal (Figs. 5.4b and 5.5). After the release of the distal forearm fascia, the median nerve comes in direct vision at its entrance into the proximal part of the carpal tunnel. Meticulous dissection under loop magnification prevents iatrogenic damage to the palmar cutaneous branch of the median nerve at its course on the distal forearm.

The second 10–12 mm distal skin incision is longitudinal at the level of the exit of the carpal tunnel following the "Taleisnik's line" (Fig. 5.6). This incision should always be placed into a palmar skin crease for an aesthetically more appealing scar. After the superficial dissection of the

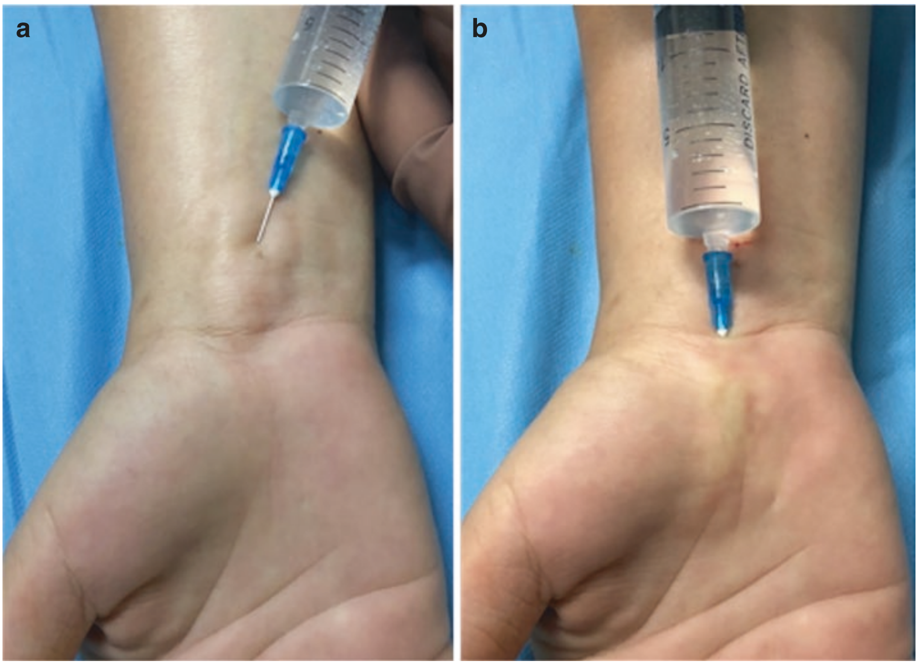

Fig. 5.2 The mixture of local anaesthetics is injected firstly under the skin proximal to the palmar wrist crease until a bump is created (**a**) and then under the skin from the wrist crease up to the distal incision (**b**). No anaesthetic is injected bellow the TCL in the carpal tunnel

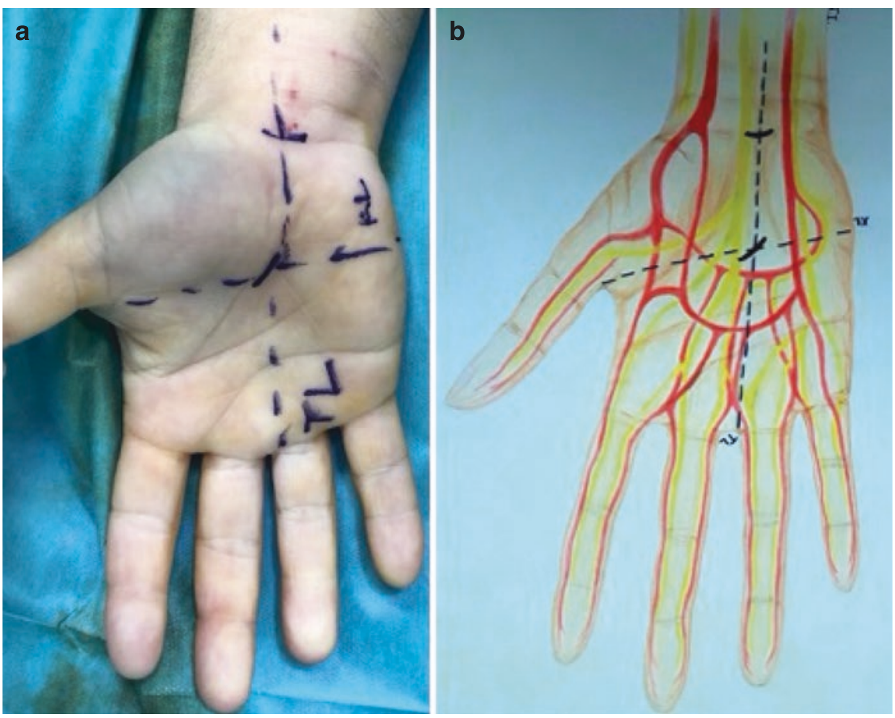

Fig. 5.3 (**a**) Pre-operative drawing of the two incisions. The proximal 1.5 cm incision is a transverse incision ulnar to flexor carpi radialis tendon in line with the Taleisnik's line (TL). The distal 1 cm incision is at the intersection of Taleisnik's and Kaplan's line (KL), with longitudinal or oblique direction to be more aesthetically appealing. (**b**) Schematic of the Taleisnik's and Kaplan's lines

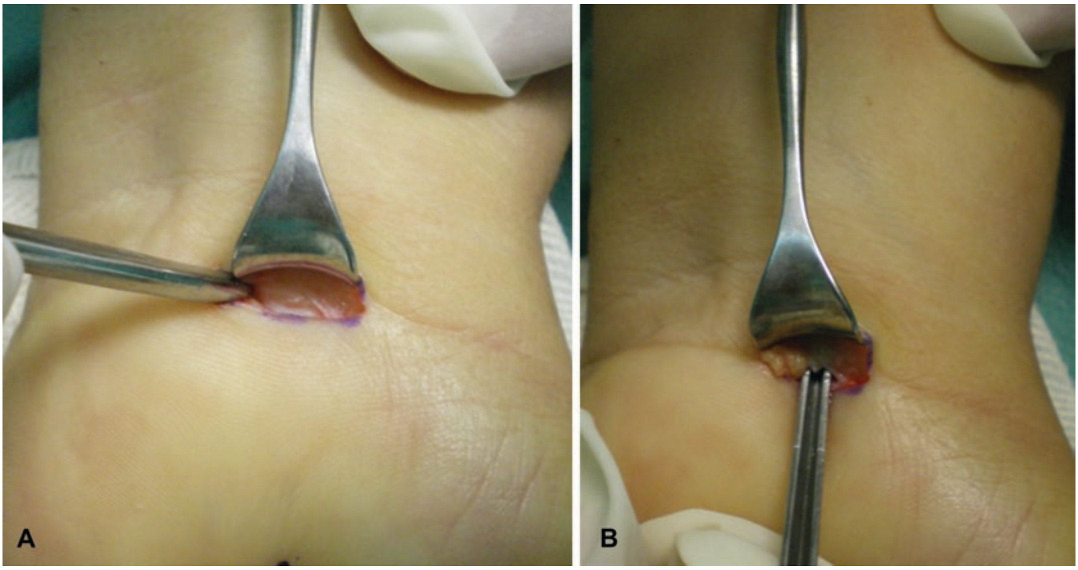

Fig. 5.4 (**a**) The palmaris longus is identified in the proximal incision and retracted radially. The forearm fascia is then incised proximally to reveal the median nerve. (**b**) Insertion of the grooved knife guide into the proximal incision from distal to proximal direction

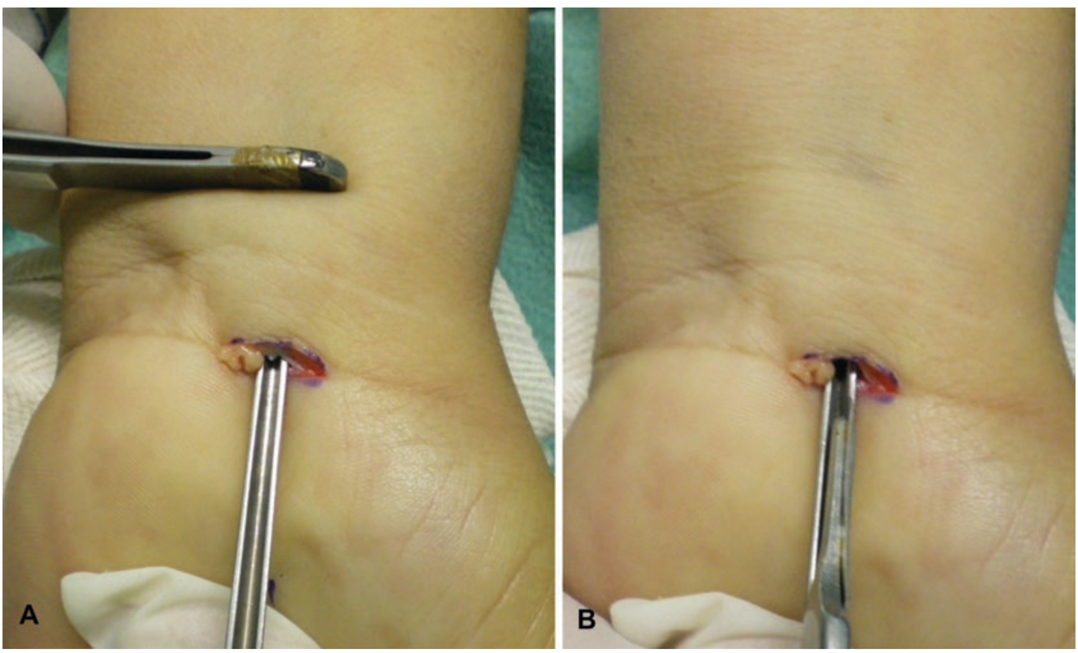

Fig. 5.5 (**a**) Insertion of the grooved knife guide into the proximal incision with distal to proximal direction. (**b**) Incision of the distal forearm fascia for approximately 2 cm with a knife sliding within the guide from distal to proximal

subcutaneous fat under the glabrous skin, opening the palmar aponeurosis the deeper "soft-substance" fat is recognized indicating the outlet of the carpal tunnel. Then, the slightly curved tip grooved knife guide is introduced from the proximal incision directed distally, in the same direction as the Talaisnik's line, and is gently passed distally through the distal incision

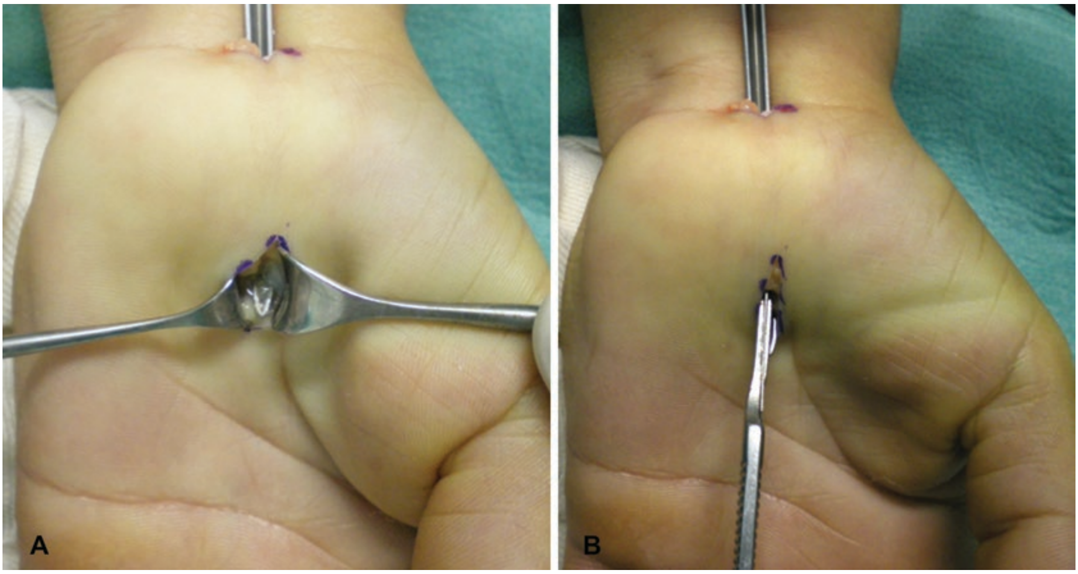

Fig. 5.6 (**a**) Insertion of the grooved knife guide from the proximal incision to the distal incision. (**b**) The knife, with the cutting edge of the scalpel facing upwards, is sliding within the guide from proximal to distal incising the transverse carpal ligament

(Fig. 5.6a). The knife guide turned slightly to an ulnar inclination of 20°, in order to avoid damaging possible trans-ligamentous course of the thenar motor branch of the median nerve. The knife, with the cutting edge of the scalpel facing upwards, is passed from distal to proximal (sliding within the guide) incising the transverse carpal ligament (Fig. 5.6b). At the end of the procedure the complete transection of the transverse carpal ligament is confirmed under direct vision through the proximal and distal incisions (Figs. 5.7 and 5.8) and by passing a broader blunt instrument (i.e. the needle holder tip) through the now widened carpal tunnel.

Neurolysis and excision of the synovium are not routinely performed, except in cases of hypothyroidism or possible inflammatory arthritis that may require a more extensile distal incision. The wound is irrigated with normal saline, and the skin is closed with absorbable sutures and covered by sterile gauzes and bandage.

Postoperative Care

The patient is instructed to elevate the arm and mobilize his fingers several times a day, with the wrist in extension to avoid irritation of the incised TCL by the finger flexor tendons. The long acting ropivacaine local anaesthetic is helping the patient to avoid discomfort for more than 12 hours. Paracetamol orally up to 3 g the first day, is usually enough for analgesia, but most of the patients do not need more than one tablet. The use of the hand is allowed as tolerance. The skin incisions are healed after the first week, and the patient is encouraged to gradually exercise and use the hand during the second week in order to regain the grip strength.

Results

The senior author has applied this technique since January 1995 and has operated on over eleven hundred hands. There were three patients in which the two-incision technique was intra-operatively abandoned and switched to open carpal tunnel release. This happened in manual labor workers with very thick palmar skin and dense subcutaneous fat, which didn't allowed adequate visualization of the carpal tunnel entrance and outlet through the two small incisions.

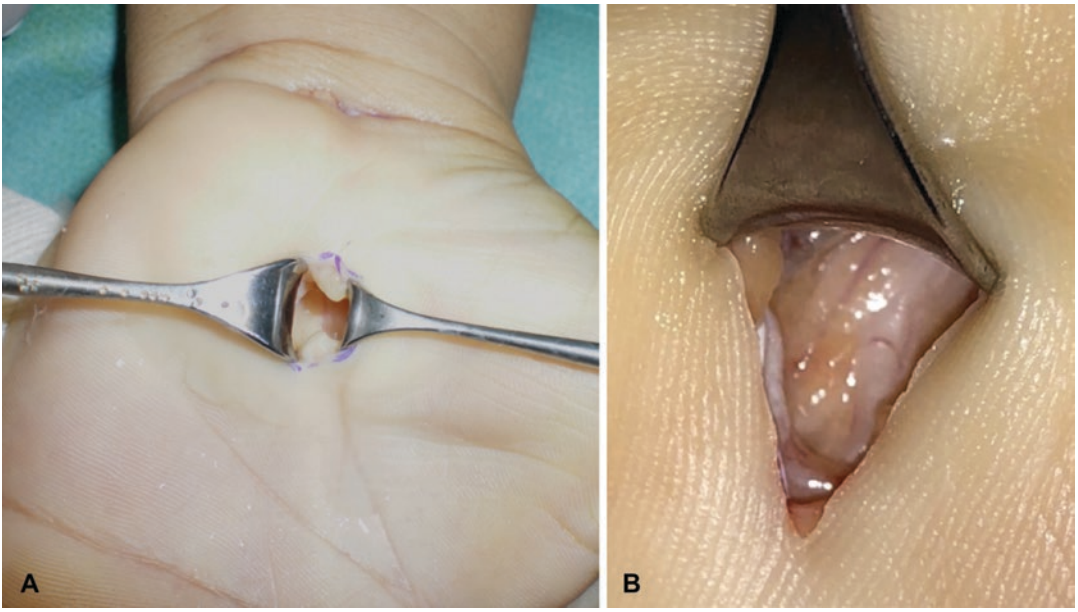

Fig. 5.7 (**a**, **b**) After the release of the transverse carpal ligament, direct inspection of the median nerve through the distal incision

Fig. 5.8 Final appearance of the two cross aligned incisions before wound closure

The although rare but well recognized in the literature early complications are incomplete release of TCL, neuropraxia or injury to the median or ulnar nerve, inadvertent entry to Guyon's canal, injury to the palmar cutaneous or recurrent motor branch of the median nerve and injury to the superficial palmar arch or ulnar artery. The late complications are scar tenderness, loss of grip strength, pillar pain, and rarely the reflex sympathetic dystrophy or complex regional pain syndrome (CRPS), and bowstringing of flexor tendons. Pillar pain is a frequent complication of both open and endoscopic release procedures.

In a recent survey, we reviewed 189 patients with carpal tunnel syndrome who had treated with two-incision mini open technique and had a minimum follow up of 3 months. One of the current chapter authors (F.P.) has conducted all patients through a telephone questionnaire to evaluate the recurrence, painful scars, pillar pain and CRPS. None of the patients complained for neuroma formation, thenar atrophy, or insensate skin at the palm or distal forearm. These results were compared with the outcomes of 643 patients who were treated with the conventional open approach and 144 patients who were treated with minimally invasive surgery (MIS) using Knifelight technique. The findings of the comparison demonstrated no

Table 5.1 Results of comparison between open carpal tunnel release (OCTR), minimally invasive surgery (MIS) using Knifelight technique and two-incision mini open technique for carpal tunnel syndrome

	Group A OCTR	Group B MIS-Knifelight	Group C Two-incision
N (patients)	643 (65.8%)	144 (14.7%)	189 (19.3%)
Recurrence	6 (0.93%)	2 (1.4%)	0
Painful scars	12 (1.7%)	2 (1.4%)	0
Pillar pain	9 (1.4%)	0	0
Complex regional pain syndrome	8 (1.2%)	0	2 (1.0%)

recurrence and no painful scars for the two-incision technique, no pillar pain for both the mini open with the Knifelight and the two-incision decompression (Table 5.1). There was a trend from more CRPS in the open and two-incision techniques. Similarly, there were more patients with recurrences, painful scars in the open and the Knifelight decompressions (Table 5.1).

Discussion

OCTR is an operation easy to perform and in majority of patients it leads to relief from symptoms with a low complication rate. The overall success rate of OCTR is more than 95% with a complication rate of less than 3%. To minimize trauma and post-operative complications, several modifications to the length, location and shape of the incision in OCTR have been described. One of the modifications of classical OCTR is to make a limited transverse incision of ≤2 cm in the same location as classical OCTR. Another modification is a limited open release performed by Atik et al in 2001 [14]. Studies have found no difference between patients who undergo bilateral simultaneous OCTR with modified techniques when compared with classical in terms of the post-operative complication rate, hospital stay, time to return work and the overall cost.

The first ECTR was performed by Okutsu and his colleagues in Japan in 1987 [15]. Later several modifications of the endoscopic technique have been described in the literature, but the underlying principle is the same: to release transverse carpal ligament. ECTR techniques can be carried out either with single portal or with dual portal techniques depending on the number of ports used to access the carpal tunnel. The two most commonly used techniques are the single-portal technique described by Agee [16] and the two-portal technique described by Chow [17]. The reported success rates for surgical treatment range from 70% to 90%.

In an extensive review of all articles on ECTR covering six different types of techniques, Jimenez et al. found that the endoscopic release techniques offer similar success and complication rate as open techniques [18]. The overall success rate for ECTR was 96.52% with a complication rate of 2.67% and a failure rate of 2.61% [18]. The Cochrane database group reviewed all available evidence from randomized controlled trials comparing various surgical techniques in terms of efficacy in relieving symptoms, promoting early return to work and post operative complications and found no strong evidence to favour alternative surgical techniques compared to the standard open technique [19]. More specifically, the authors found conflicting evidence in support of endoscopic release in leading to an earlier return to work and/or activities of daily living when compared to open CTR [19]. These findings have been replicated by another meta-analysis study of randomized controlled trials comparing endoscopic and open carpal tunnel decompression, which also found no conclusive evidence favouring ECTR with regard to symptom relief and return to work [20]. However, they found that ECTR was associated with reduced scar tenderness and increase in pinch grip and pinch strength at 12 weeks follow up. The most common complications noted by the authors were paresthesia of the ulnar and median nerves, injury to superficial palmar arch, CRPS, flexor tendons lacerations and incomplete division of TCL.

As in other fields of surgery, less invasive techniques have been introduced into carpal tunnel surgery to facilitate earlier return to work and reduce post-operative pillar pain. The two small cross aligned incisions (TSCAI) surgical approach is causing minimal trauma and at the same time allows direct visualization of the median nerve. The transverse proximal incision always carried out under loop magnification allows protection of the superficial sensory branch for the palm, thus avoiding neuroma formation. The introduction of the thin grooved knife guide is safe when the patient is able to communicate and react in case of nerve encroachment. Directing upwards the cutting edge of the knife driven by the inserted guide, against the TCL with a slight ulnar inclination has been proven safe, as there has been no accidental injury of the thenar motor branch. The knife guide is a grooved metallic instrument of 4 mm in width and 2.5 mm in depth having a triangular cross section (Fig. 5.1). Its dimensions are considerably smaller compared to the bulk of the endoscopic guide. Thus entering the carpal tunnel is less irritable for the median nerve, and this might be one of the reasons of lower rates of CRPS with this technique.

In conclusion, the TSCAI technique with the use of few surgical instruments under local anaesthesia described above is a safe and reliable alternative treatment option for the release of the TCL to relieve the symptoms of the carpal tunnel syndrome.

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