Recurrent Carpal Tunnel Syndrome

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Scott G. Edwards and Joshua W. Hustedt

Introduction

Carpal tunnel syndrome is the most common peripheral nerve compression syndrome, occurring in approximately 7 per 10,000 persons [1]. Surgical release of the transverse carpal ligament ("carpal tunnel release") usually has excellent clinical outcomes with return to function and pain reduction [2]. However, complications and failures can occur, varying from 3% to 25% of cases reported in the medical literature [3–5].

Recurrent carpal tunnel symptoms are a challenging problem that is often clinically underestimated [3]. Revision surgery for persistent symptoms is needed in 3–12% of patients [3, 6]. Unfortunately, results following revision carpal tunnel release are disappointing, with 40% of patients reporting unfavorable results and 95% of patients with residual symptoms following revision surgery [4, 6]. Herein, we review the common etiologies of recurrent carpal tunnel syndrome and present treatment options for clinical practice.

S.G. Edwards (✉)
Department of Orthopedics, University of Arizona College of Medicine-Phoenix, 320 N. 10th St., Suite A, Phoenix, AZ, USA

Center for Orthopedic Research and Education, Phoenix, AZ, USA
e-mail: scott.edwards@thecoreinstitute.com

J.W. Hustedt
Department of Orthopedics, University of Arizona College of Medicine-Phoenix, 320 N. 10th St., Suite A, Phoenix, AZ, USA

Clinical Evaluation

Any evaluation of a patient that returns complaining of persistent or recurrent carpal tunnel symptoms must include a thorough evaluation of all possible etiologies. The most common etiologies of recurrent carpal tunnel symptoms include incomplete release of the transverse carpal ligament, median nerve fibrosis, and iatrogenic nerve injury. However, the clinician must be certain to also evaluate the patient for other causes of hand pain, including other upper extremity peripheral neuropathies.

The largest clinical clues when evaluating a patient with recurrent carpal tunnel syndrome come from the time course of the patient's symptoms. Each patient can be placed into one of three groups: patients who experience persistent symptoms, patients who experience recurrent symptoms, and patients with new onset symptoms following surgical release. Persistent symptoms refer to a specific complaint that was present prior to surgery and was never relieved. Recurrent symptoms differ in that the patient did experience relief after surgery; however, the same symptoms that were present prior to release have now

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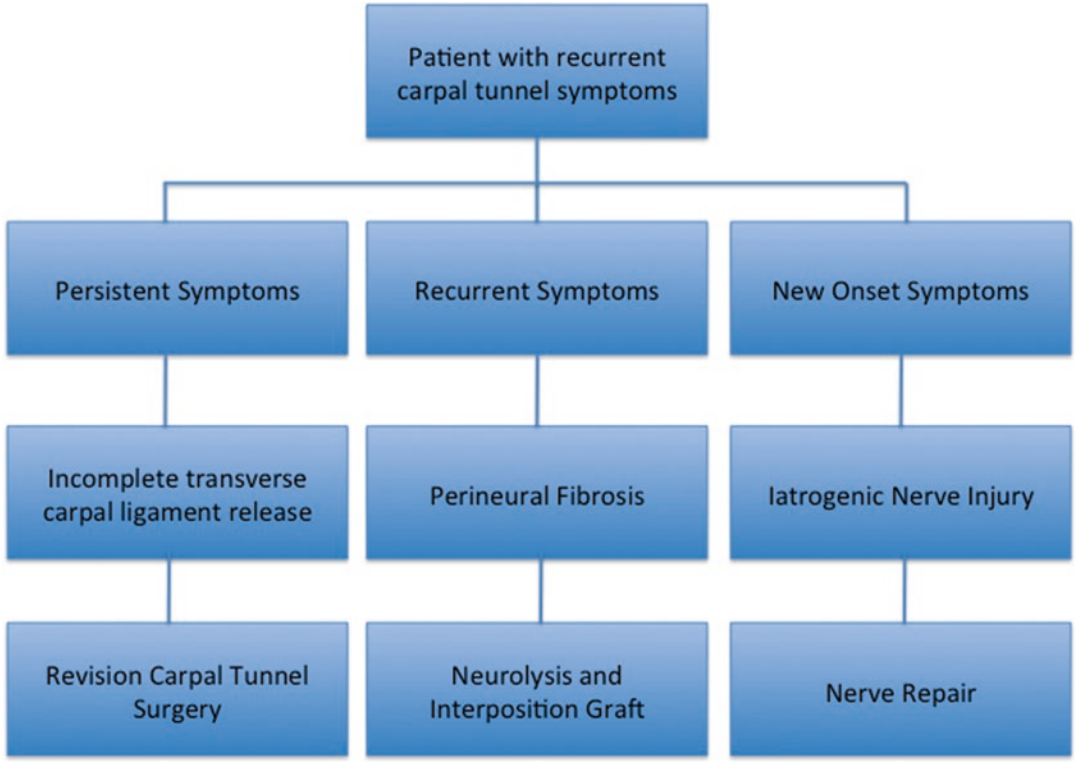

Fig. 15.1 Decision-making tree for diagnosis of recurrent carpal tunnel symptoms following carpal tunnel surgery

returned. Lastly, new symptoms refer to a unique complaint that was not present prior to surgery (Fig. 15.1) [7].

Persistent Symptoms

Persistent symptoms are most commonly caused by incomplete release of the transverse carpal ligament. A recent study analyzing 50 patients who required revision carpal tunnel release found that 58% of patients had persistent symptoms due to incomplete release. Compression occurred at the distal transverse carpal ligament in 56% of cases and at the proximal antebrachial fascia at the wrist crease in 44% of cases [3]. Endoscopic carpal tunnel release has often been cited as a risk factor for incomplete release of the transverse carpal ligament, particularly in early studies of endoscopic release [8]. However, meta-analysis data on endoscopic versus open releases find that endoscopic release is comparable to open release in regard to most complications, including the need for revision surgery and rate of persistent symptoms. The only difference is a slightly higher risk of catastrophic complications with endoscopic release, most commonly from complete transection of the median nerve [9].

Persistent symptoms may also be caused by chronic nerve injury. Relief of pain and numbness in a chronically compressed nerve may take many months to resolve even with complete surgical release. Often, exacerbating symptoms (such as nighttime pain) will be relieved with transverse carpal ligament release, but numbness will persist and gradually improve over time as the median nerve returns to full function [10]. Studies have shown that the best way to monitor gradual nerve function over time is with periodic clinical sensation assessment with Semmes-Weinstein monofilaments [11]. Careful clinical follow-up, therefore, is key in determining gradual improvement, particularly in patients with significant preoperative compression.

Persistent symptoms that fail to resolve should alert the clinician to examine other etiologies of hand and wrist pain. Even with careful history, thorough physical exam, and testing, the diagnosis of carpal tunnel syndrome in the patient with wrist and hand pain is not always straightforward. Hand pain can easily be confused with other common problems such as cervical radiculopathy, radial sensory neuritis, De Quervain's tenosynovitis, carpal-metacarpal thumb arthritis, ulnar neuropathy at the elbow, or trigger finger. Other metabolic causes for neuropathy must also be considered including diabetes, alcoholism, vitamin deficiencies, HIV, chemotherapy agents, and adverse reactions from medications. In combination with slightly abnormal but clinically inconsequential electrodiagnostic studies, these patients may be incorrectly indicated for carpal tunnel release and result in persistent symptoms after surgery.

Recurrent Symptoms

Recurrent symptoms are defined as a return of preoperative symptoms after a period of complete or partial relief following surgery. The most common cause of recurrent symptoms is the formation of excessive scar tissue surrounding the median nerve (perineural fibrosis) or postoperative edema (swelling) causing median nerve compression. The patient with recurrent symptoms will often complain of the exact same symptoms experienced preoperatively. It is, therefore, essential that clinicians document preoperative symptoms carefully, to aid in evaluation of postoperative recurrent carpal tunnel syndrome.

The time interval to recurrent symptoms can vary widely from patient to patient. In a retrospective review of recurrent carpal tunnel symptoms, the average time from the initial surgery to recurrence was 21 months but ranging from 14 days to 8 years [3]. In another study the average time to recurrence was 4.8 months, with the most common complaint consisting of numbness in the median nerve distribution [12]. While recurrent latency periods vary widely, the key to determining whether a patient has recurrent symptoms is some period of initial relief (which represents full transverse carpal ligament release), followed by return of preoperative symptoms.

New Onset Symptoms

Perhaps the most frustrating complaint following carpal tunnel release is the onset of a new symptom that was not present prior to surgical release. While the causes of new onset symptoms are numerous, the most common in the immediate onset is iatrogenic nerve injury. Patients may complain of new onset pain, trigger finger, and incisional "pillar" pain, which are largely separate issues from the original diagnosis. Worsening numbness or loss of two-point discrimination should alert the clinician to suspect iatrogenic nerve injury [13].

While rare, iatrogenic nerve injuries have been shown to occur. In revision surgeries iatrogenic nerve injury occurred in 3–6% of cases [3, 6]. Transection of the median nerve has also been documented, in one series occurring in 1 of 24 revision procedures and in another series in 2 of 200 revision procedures [6, 14]. Iatrogenic injuries can occur to the palmar cutaneous branch, recurrent motor branch, or median nerve as well as to digital nerves [10].

Diagnostic Studies

Clinical examination maneuvers, diagnostic studies, and diagnostic injections are all options in evaluating a patient with recurrent carpal tunnel syndrome. These studies are particularly valuable when preoperative studies are available for comparison. Provocative maneuvers, such as Phalen's and Durkan's tests and Tinel's sign, are useful in eliciting compression in the carpal tunnel, especially when compared to the contralateral side and to preoperative assessments. Studies have shown that up to 50% of patients with recurrent carpal tunnel syndrome will have positive Phalen's and Tinel's tests, as well as experience loss in grip strength and limitations in performing fine motor tasks [15, 16]. In addition to provocative exams, diagnostic steroid injections have been shown to be helpful isolating pathology to the carpal tunnel.

Table 15.1 Clinical recommendations based on electromyographic findings following carpal tunnel release

EMG findings after surgical release	Clinical recommendation
Improvement	Monitor clinically
Worsening	Iatrogenic nerve injury: surgical exploration
Same	Consider other etiologies/ confirm diagnosis with additional diagnostic studies

In one study examining patients with recurrent carpal tunnel syndrome, positive Durkan's and Phalen's tests in the presence of relief of symptoms from corticosteroid injection combined to provide a clinical diagnosis of median nerve compression with a sensitivity of 100% and a specificity of 80% [16].

Electrodiagnostic (EMG) studies can also be helpful in determining the etiology of recurrent symptoms, particularly when preoperative studies are available for comparison [3]. EMG studies are particularly helpful when showing either clinical improvement or worsening (Table 15.1). If EMG findings are improved after surgical release, clinicians may monitor for clinical improvement over time. If EMG findings are worsened after surgery, clinicians should suspect iatrogenic nerve injury or exuberant postoperative perineural fibrosis. Equivocal EMG findings are more difficult to interpret and should lead clinicians to examine for other sites of compression or attempt a diagnostic intra-carpal tunnel steroid injection. In addition, imaging studies, particularly MRI, may be helpful to rule out other causes of compression within the carpal tunnel such as overly abundant tenosynovitis, fibrosis, or any space-occupying mass. MRI does not, however, reliably exclude incomplete release of the transverse carpal ligament [17].

Revision Carpal Tunnel Surgery

Revision carpal tunnel surgery can be difficult due to excessive scar formation and perineural fibrosis distorting normal anatomy and surgical planes. Therefore, it has been recommended that the incision for revision surgery be made ulnar to the prior incision, as the median nerve may be adherent to the underside of the previous incision and is at risk during the initial dissection. In our experience, however, the median nerve usually resides away from the original incision and remains adherent underneath the radial leaflet of the incised transverse carpal ligament in close proximity to the tendon of the flexor pollicis longus. Certain authors also advocate for the extension of the incision, either proximal or distal, to access native tissue planes and identify the median nerve prior to surgical exploration in the prior surgical field [10]. This technique offers significant advantages in the setting of significant perineural fibrosis.

Revision for Persistent Symptoms

Patients who experience persistent carpal tunnel symptoms are often treated for incomplete release of the transverse carpal ligament. Revision surgery in this case is utilized to identify any existent transverse fibers, which are transected. The most common site of persistent transverse fibers is at the distal end of the carpal tunnel. We recommend proceeding distally with the dissection until the perivascular fat of the superficial arch is encountered. The second most common site of compression is proximal transverse fibers near the wrist crease or antebrachial fascia at the wrist [3, 6]. Additionally, proximal sites of compression can also occur including compression by the pronator teres and the flexor digitorum superficialis muscles. Both of these muscles may have a fibrous band or edge compressing the nerve [7].

Revision Carpal Tunnel Release for Recurrent Symptoms

Patients who experience recurrent carpal tunnel symptoms are often treated for perineural fibrosis of the median nerve. The treatment of perineural fibrosis consists of both removal of scar tissue (neurolysis) and interposition grafting with either autograft or allograft to prevent future postoperative scar formation. Some authors have advocated

an internal neurolysis for all recurrent carpal tunnel syndromes [7]. This involves opening the epineurium using microsurgical techniques until normal perineurium is exposed. Care must be taken to protect the perineurium to preserve the blood-nerve barrier. Although shown to be of no benefit in routine primary carpal tunnel surgery, it has yet to be studied thoroughly in the revision setting, but many authors advocate its benefits anecdotally [7]. Regardless of technique, the fibrosis surrounding the median nerve needs to be carefully dissected away from the epineurium to prevent future proliferation of fibrosis against the nerve and consequent recurrent compression.

Perineural fibrosis is inevitable after carpal tunnel surgery and little can be done to prevent its formation. The clinical consequences of this fibrosis, however, are variable and can be modulated [18]. Since we cannot stop perineural fibrosis from forming, the focus should be on protecting the nerve from its contractile effects if perineural fibrosis has proven to be a problem in the past. Interposition grafting has been recommended to "insulate" the nerve from inevitable scar tissue formation in the setting of revision surgery where perineural fibrosis has been proven to be an issue [19]. Both non-vascularized and vascularized flaps are available for interposition grafts. The choice of which surgical technique to use is largely dictated by the surrounding soft tissue bed and the appearance of the nerve. The treatment should be aimed at logically addressing the underlying pathology. When the nerve appears well perfused and fibrosis is the main culprit, then a vascularized flap may not be necessary. However, if there are dysvascular areas surrounding the nerve, then a vascularized flap may be preferred.

Autologous non-vascularized interposition grafts may include dermal fat grafts from the abdomen [20], hypothenar fat grafts (not to be confused with hypothenar fat flaps) [21], synovial grafts [22], and saphenous vein grafts [23]. Autograft saphenous vein wrapping of the median nerve has been shown to effectively prevent neural fibrosis while improving neovascularization [24, 25]. Clinical outcomes after autologous vein grafting have been good with patient satisfaction of 98%, two-point discrimination improvement in 80%, and signs of improvement on EMG testing [21]. Allograft saphenous or umbilical veins may be used, and in our experience, perform as well as autografts without the donor morbidity and prolonged operative time. Studies have shown, however, that allograft vein wraps do not promote the same epineural neovascularity as seen in autografts [26]. The clinical significance of this, however, remains unclear.

Similar to vein wrapping, bovine xenograft collagen conduit nerve wraps have also been shown to have similarly improved clinical outcomes [27]. The advantages of collagen wraps are that they appear to have all the mechanical barrier protection and physiologic incorporation of autograft veins, without the donor morbidity and prolonged operative time [28, 29]. The obvious disadvantage of these xenograft collagen wraps is their costs. Bovine collagen wraps are well established and most extensively studied, but porcine small intestine submucosa (SIS) recently has been modified for this purpose and reported to have advantages of added modulating factors to promote nerve health [30]. SIS has been criticized for inciting unacceptable inflammation for other indications such as in rotator cuff and cardiac surgery [31, 32]. But recent refinements in SIS processing may have solved this problem, but to date this claim has not been validated clinically [33].

Another option for interposition grafting is a vascularized graft. The proposed advantages of the vascularized flaps include promotion of neovascularization of the epineurium and reduction of resorption and host rejection. Several vascularized flaps have been described for the purposes of carpal tunnel revision surgery including the hypothenar fat flap [34], flexor synovium flap [35], abductor digiti minimi flap [36], palmaris brevis flap [37], lumbrical flap [38], flexor digitorum superficialis flap [21], pronator quadratus flap [39], and vascularized free flaps [27]. Perineural fibrosis causing compression distally may best be addressed with flaps from the abductor digiti minimi, palmaris brevis, or lumbrical muscles.

The most popular vascularized interposition graft is the hypothenar fat flap, largely due to the fact that the most common location for postoperative fibrosis occurs in the central portion of the carpal tunnel adjacent to this flap. The flap is based on an ulnar artery pedicle and is brought into final position between the median nerve and the radial remnant transverse carpal ligament. The flap is harvested through the same surgical incision as the index surgery, though slightly extended, is technically simple, and does not sacrifice any hand function (as opposed to the muscle-based flaps) [40]. Clinical outcomes of hypothenar fat flaps have been excellent, with 88–95% of patients reporting satisfaction with the procedure [34, 41]. If perineural fibrosis is most evident in the proximal portion of the carpal tunnel and the hypothenar fat flap may not have adequate coverage, a flap from the flexor superficialis or pronator quadratus muscle may be used. The flexor superficialis muscle is easy to identify since its belly extends distally on its tendon further than any other muscle from the forearm. After identifying the muscle belly that extends the furthest distally, elevate a 4 cm slip of the muscle belly from the proximal portion of the tendon, and rotate it distally based on its remaining intact myotendinous junction. It is important to identify the epitendinous perforating vessel supplying the flap. Sparing this vessel at the myotendinous junction limits the dissection distally. The muscle pedicle is draped over the nerve and secured radially and ulnarly with absorbable suture [21].

Iatrogenic Nerve Injury

When iatrogenic nerve injury is suspected, there is almost always an indication to return to the operating room for operative exploration. While short periods of observation may be warranted in certain situations, no improvement after 3 months, especially with worsening electromyography findings, is an indication for surgical exploration. Surgical exploration requires little additional morbidity, while offering significant benefits to long-term function [10]. When a nerve injury is encountered, treatment options include primary repair, artificial neural tube grafting, or interposition graft with autograft harvested from the medial antebrachial cutaneous nerve or sural nerve (utilized for larger grafts) [7, 42].

Outcomes

The results of revision carpal tunnel surgery vary widely, with some patients reporting improvement, but with 41–90% of patients reporting at least some residual symptoms [11]. Clinical decision-making for the hand surgeon is made difficult by the lack of good comparative outcomes data. Most data on recurrent carpal tunnel surgery involves small series of patients with poor or no controls and inconsistent outcomes metrics [43].

Authors have attempted to examine variables associated with outcomes of revision carpal tunnel surgery. Studies examining reasons for poorer outcomes have identified worker's compensation patients, higher preoperative pain scores, use of preoperative pain medication, and normal preoperative EMG results to portend a negative result after revision surgery [11, 44]. Studies examining variables that increase success have found initial surgical approaches with short or transverse incisions (leading to higher rates of incomplete transverse carpal ligament release), activity-related symptoms (only exacerbating symptoms present), positive Phalen's sign, and nocturnal symptoms are all signs of a good prognosis with revision surgery [11]. These guidelines, however, may be too narrow for our broad patient population, and systematic strategies, such as the ones previously described, may be more clinically relevant.

Ultimately, the expected benefit of revision surgery is based on the etiology of the underlying nerve compression. Patients with persistent carpal tunnel symptoms due to incomplete transverse carpal ligament release should expect to have similar successful results as patients undergoing primary carpal tunnel release. Patients, however, that have recurrent carpal tunnel syndrome due to perineural fibrosis may have worse outcomes. While there has yet to be a prospective study to identify the most effective treatment for

recurrent carpal tunnel symptoms, there is a preference in the literature for revision surgery with hypothenar fat pad interposition grafting [4, 6].

Summary

The patient with recurrent carpal tunnel symptoms provides a difficult clinical scenario for the hand surgeon. It is crucial that a proper diagnosis be obtained to determine the underlying etiology of the recurrent symptoms. The timing of the presentation of the symptoms is often the most valuable clue in the diagnostic process. Patients with new onset symptoms should lead to a suspicion of iatrogenic nerve injury. Patients with persistent symptoms should be evaluated for incomplete transverse carpal ligament release and other causes for upper extremity neuropathy. Finally, patients with recurrent symptoms should be evaluated and treated for perineural fibrosis. Ultimately, the etiology of the recurrent symptoms needs to be correctly identified and then proper surgical management can be undertaken.

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