Immediate and durable clinical improvement in the non-operated hand after contralateral surgery for patients with bilateral Carpal Tunnel Syndrome

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Abstract

Background Little is known about clinical improvement in the non-operated hand after unilateral surgery for patients who present with bilateral carpal tunnel syndrome (CTS). In this prospective study of patients with bilateral CTS, we evaluated the clinical effects on the non-operated hand following unilateral contralateral carpal tunnel surgical release.

Material and Methods During a consecutive period of 22 months, 69 patients with bilateral CTS underwent unilateral open carpal tunnel release. Bilateral subjective and objective evaluations were performed pre-operatively, at days 2, 15 and 180 after surgery. Subjective evaluations, analysed with Student *t* test, included the Boston-Levine symptom severity score and a visual analogue scale including pain, nocturnal symptoms and numbness. A telephone survey was conducted 12 months after surgery.

Results The Boston-Levine severity score of the contralateral non-operated hand decreased from 2.70 pre-operatively to 1.70 at 2 days ($p < 0.001$). The visual analogue pain score decreased at 2 days for 61 patients (88 %), whereas the nocturnal symptoms decreased or disappeared in 63 cases (91 %) and the paresthesia in 52 cases (75 %) ($ps < 0.001$). These beneficial effects were stable in time with no statistically significant change at 180 days. Overall, 58 patients (84 %) observed a total resolution or a significant improvement in their symptoms at 6 months. At 12 months, 100 % of patients responded to a telephone survey. Fifty one of them (74 %) reported minimal or no symptoms on the non-operated

hand. Linear regression (analysis of variance [ANOVA]) showed that gender, age, professional status, duration of pre-operative symptoms and severity of electrophysiological disturbances were not predictive of post-operative evolution in the non-operated hand after unilateral surgery for CTS.

Keywords Bilateral surgery · Carpal tunnel syndrome

Background

Carpal tunnel syndrome (CTS) is often a bilateral condition and has been previously reported to occur in 59–87 % of patients [6, 20, 24]. In addition, it has been suggested that the majority of patients who complain of unilateral CTS have neurophysiologic impairment in their other asymptomatic hand, which will most likely develop symptoms at a later date [24]. Investigations concerning clinical improvement of the non-operated hand after unilateral surgery for patients who present with bilateral CTS are scarce and are comprised of small patient series. McLaughlin and Pizzi [20] reviewed 45 patients with bilateral CTS following unilateral surgery on the more severely affected hand. At 5 years, 73 % completed a questionnaire which revealed a decline or disappearance of symptoms in the non-operated hand in 58 %. Similarly, Yoon et al. [33] reported that 15 of 20 patients with bilateral CTS had diminished symptoms in the non-operated hand within 1 year following surgery, even if electromyography did not correlate with the patients' perception. Conversely, in a prospective study conducted in 66 patients with bilateral carpal tunnel involvement, Afshar A. et al. [1] found no improvement in the non-operated hand 6 months after unilateral surgery. This included subjective and objective findings, including electromyography.

In this prospective study of patients with bilateral CTS undergoing unilateral carpal tunnel release on the more

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affected side, we investigated the clinical course of the non-operated hand. We compared the evolution of symptoms at 2, 15, 180 and 360 days after surgery. Gender, age, professional status, duration of pre-operative symptoms and severity of pre-operative electrophysiological disturbances were analysed as possible predictors of outcome.

Material and Methods

During a period of 22 consecutive months, 69 patients (45 female, 24 male) with a median age of 53 (24–82) underwent unilateral carpal tunnel release. All patients had symptomatic bilateral CTS based on personal history, clinical examination (Fig. 1) and electrophysiologic studies (Fig. 2). Symptoms were generally asymmetric when comparing both hands. Consistent with the common practice inspired from the protocol advocated by G. Phalen, and based on patients' preference, unilateral surgery was decided on the most symptomatic hand, independent of hand dominance (dominant hand operated in 42 patients, 61 %; right hand operated in 42 patients, 61 %; left side operated in 27 patients, 39 %). Patients were categorized according to duration of symptoms prior to surgery: inferior to 6 months (3 patients, 4 %), from 6 to 12 months (12 patients, 17 %), from 12 to 24 months (17 patients, 25 %) and more than 24 months (37 patients, 54 %). Patients were further classified based on professional activity: mainly administrative work 18 cases (26 %), mainly manual work 17 cases (25 %), other (homemaker, unemployed, retired) 34 cases (49 %).

All patients were operated with a limited open approach under intravenous regional anaesthesia. No splints were used post-operatively, and patients received anti-inflammatory medication for 2 days post-operatively (acemetacin-Tilur Ret®-2×90 mg/day).

The objective evaluation for both the operated and non-operated hands was performed pre-operatively, then at 15 and 180 days after surgery. This included Tinel's sign, Phalen's manoeuvre, Durkan test as well as the Weber two-point discrimination test.

To measure patients' subjective perception of clinical changes after surgery, we used the Boston-Levine questionnaire for both operated and non-operated hands (pre-operative score and post-operative scores at days 2, 15 and 180). Based

on a previous study conducted by Amirfeyz et al. [2], we considered that a decrease of 0.47 or more in the Boston-Levine score correlated with a statistically significant improvement. Subjective evaluations also included assessment of pain, nocturnal symptoms and numbness using a visual analogue scale (VAS) at days 2, 15 and 180 as well as a global evaluation at 6 months for those three items as to whether or not symptoms had partially or completely subsided. Twelve months after the operation, a telephone survey was conducted and patients were asked whether symptoms in the non-operated hand had subsided completely, subsided partially, had never disappeared or had recurred.

We used paired *t* test to compare scores between time periods (e.g., pre-operation vs. 2-day follow-up). We used linear regression or analysis of variance (ANOVA) to investigate if gender, age, professional status, duration of pre-operative symptoms and severity of electrophysiological disturbances were predictive of the decrease in severity in the non-operated hand. Figure 3 summarizes the evaluation tools for both operated and non-operated hands before and after unilateral surgery.

Results

Following surgery, 65 patients (94 %) were satisfied and reported at days 2 and 180 that symptoms had decreased or resolved in the operated hand. For these patients, no recurrence was noted after the operation at 12 months. Four patients (6 %) did not observe significant improvement in the operated hand.

On the contralateral non-operated hand, the Boston-Levine severity score showed a statistically significant decrease immediately after the operation (2.74 pre-operatively to 1.70 at day 2, $p<0.001$) and a further decrease at 15 days ($m=1.42$, p day 2 versus day 15 <0.001). This beneficial effect was stable, with no further significant change at 6-month follow-up (Boston-Levine score of 1.40 at 180 days, see Fig. 4). Of the 69 patients, 56 (81 %) had a clinically significant decrease of 0.47 points. Two days after the surgery, all VAS decreased significantly (pain dropped from 3.81 to 1.54, paresthesias from 4.95 to 1.91 and nocturnal symptoms from 4.56 to 1.90, $ps<0.001$), with a further smaller decrease until the 15-day follow-up ($ps<0.01$ for pain and nocturnal symptoms, $p=0.02$ for

Fig. 1 Clinical signs of bilateral CTS in a series of 69 patients

Bilateral irritation signs (Tinel, Phalen, Durkan)	69 / 69 patients	(100%)
Weber Test side to be operated	4.9 mm mean value	(4-12)
Weber Test contralateral hand	4.7 mm mean value	(3-12)
Thenar atrophy side to be operated	8 / 69 patients	(12%)
Thenar atrophy conrolateral side	4 / 69 patients	(6%)

Fig. 2 Bilateral CTS: pre-operative electrophysiological findings and Stevens grading. Stevens Grade 1: mild carpal tunnel defined by relative or absolute prolongation of either the sensory or palmar median nerve. Additionally, at times, the amplitude of the potential is seen to be slightly diminished. Stevens grade 2: moderate carpal tunnel, both sensory and motor latencies are relatively or absolutely prolonged. Stevens grade 3: severe carpal tunnel both motor and sensory latencies being prolonged with either an absent sensory or palmar potential or low amplitude or absent motor potential

paresthesias). Again, the beneficial effect remained stable after day 15 (Fig. 5). Six months after the operation, 61 patients (88 %) reported that pain on the non-operated side had subsided or disappeared. Sixty-three patients (91 %) noted that nocturnal symptoms had partially or totally disappeared. Fifty-two patients (75 %) reported that paresthesias had partially or totally disappeared. Fifty-one patients (74 %) reported disappearance or significant decrease of all three symptoms (pain, nocturnal symptoms, paresthesias), and an additional seven patients (10 %) reported disappearance or a significant decrease of two of the three symptoms. Nine patients (13 %) reported that only one of the symptoms had subsided partially totally, and two patients (3 %) were categorized as non-responders.

At 12 months, 69 patients (100 %) were located and responded to the telephone survey. A total of 58 patients (84 %) were considered good responders in the

non-operated hand with 58 % ($n=40$) reporting no symptoms and 17 % ($n=12$) reporting little disturbance. Four patients (6 %) were symptomatic but preferred conservative therapy. The remaining 13 patients (19 %) had carpal tunnel surgery on the contralateral hand in the intervening time due to persistence or recurrence of symptoms in eight or for other reasons in five (decompression associated with a distal radius fracture in one, preventative surgery whilst looking for a new professional position in three and before a permanent move to a developing country in one).

Statistical analysis using linear regression (ANOVA) showed that gender, age, professional status, duration of pre-operative symptoms and severity of electrophysiological disturbance were not predictive of post-operative evolution in the non-operated hand after unilateral surgery for CTS.

Fig. 3 Evaluation of operated hand and non-operated hand before and after unilateral surgery

Fig. 4 Non-operated hand: Boston-Levine score and score changes after contralateral surgery

Fig. 5 Non-operated hand: changes in VAS scores after contralateral surgery

Discussion

This study demonstrates immediate and durable clinical improvement in the non-operated hand after contralateral surgery for patients with bilateral CTS. Clinical improvement in the non-operated hand 2 days post-operatively suggests that the beneficial effect of contralateral surgery is not attributable to better load sharing between the two hands, assuming that 2 days after surgery activity and repetitive work done by the operated hand have not increased enough to lessen load on the non-operated hand. Continued relief on the non-operated hand at 6 months indicates that the beneficial effect of surgery is not attributable to anti-inflammatory medication which was only prescribed for 2 days post-operatively for all patients.

The idea that nerve compression on one site could have some effects at another site is not new. Some experimental and clinical evidence, although controversial, suggest that once a nerve is damaged, it becomes more susceptible to injury at another site. In the 1960s, Lishman and Russell proposed that changes in the interstitial tissue of the nerve “may spread freely from part to another, with the result that pathological changes in the nerve roots may, for example, influence vulnerability of the nerve at the wrist” [18]. Later on, Upton and McComas formalized the concept of the “double crush syndrome”, suggesting that impaired axonal transport might contribute to increased susceptibility for distal neuropathy in patients suffering from cervical spinal root entrapment [29].

Neurological hypotheses have been proposed to explain bilateral symptoms. Previously reported animal models suggest that chronic neuropathic pain might use different transmission patterns than thermal or acute pain [20]. Nociceptive activity in rats is conducted diffusely, including in the somatosensory cortex bilaterally. This has been correlated with clinical evidence of pain contralateral to the injury and could explain why the pain produced in one side is perceived to be bilateral [5, 26].

The role of neurocytokines has been investigated in the pathogenesis of neuropathic pain. Based on the involvement of substance P in neuropathic pain, chronic inflammation and fibrosis, Öztürk et al. [23] studied its levels in soft tissue samples in patients operated for CTS and confronted them to control groups. They found elevated levels of substance P in the transverse carpal ligament and underlying synovial connective tissue of the middle flexor digitorum superficialis tendon in patients operated for CTS. Interestingly, local substance P levels were further increased in patients treated with oral meloxicam (NSAID) prior to surgery.

“Immune activation near healthy peripheral nerves may (also) have a greater role in creating pathological pain than previously recognized” [9]. Chacur et al. [9] developed an animal model to induce sciatic inflammatory neuritis by immune activation after injecting yeast cell walls around the

sciatic nerve of rats. Low doses induced ipsilateral hindpaw allodynia whereas higher doses triggered what the authors called “mirror allodynia”, with the presence of concomitant contralateral pain.

These animal models suggest that complex neurohumoral and immune responses might regulate nociceptive signals in a way which is still poorly understood.

It is difficult to determine if long-term improvements in symptoms and function in the non-operated hand for some patients are a direct consequence of contralateral surgery or a natural course of CTS.

Pensy et al. [25] reported a notable improvement in both symptoms and function in 36 patients with CTS who were scheduled for surgery but did not ultimately have the procedure due to a variety of reasons. Although the non-operated group did not improve as much as the 24 patients who did undergo surgical release in a paired comparison, this effect was statistically significant and durable for 6 years. In a prospective cohort study of CTS amongst employees of manufacturing companies in the state of Washington comprising 733 patients with a follow-up at 1 year for 57 % of them, Silverstein et al. noted that 51 % of the patients who had both symptoms of CTS and abnormal electrophysiological findings at baseline were asymptomatic at 1 year, even if almost none of them (4 %) had normalized their nerve conduction values [28]. The long list of conditions associated with CTS makes its course difficult to predict. Beyond anatomic compressions, there is strong evidence that the co-occurrence of comorbidities that lead to fluid retention, chronic inflammation or deposition diseases influences the course of CTS or the result of surgery. The observation that daytime pain responds less well to surgery than tingling might confirm the role of inflammatory cascades in the physiopathology of CTS [32]. Other patient-related factors such as hormonal changes or BMI play a role, along with conditions associated to increased susceptibility to neuropathy such as diabetes, alcoholism or genetic mutations [19, 31].

The results of this study confirm prior findings from two small studies [20, 33]. However, contralateral symptomatic improvement has been quite variable in previously published reports and ranges from 0 to 75 % [1, 20, 33]. In this study, contralateral improvement was observed in 84 % of patients. Different factors might contribute to this dispersion. Inclusion criteria and loss of follow-up might introduce selection and response biases. For instance, if all the patients excluded from the initial pool of patients reported by Afshar et al. [1] had an improvement on the contralateral side after surgery, the percentage of those patients with improvement would increase from 0 to 36 %. Conversely, if all 71 patients who had bilateral surgery in the McLaughlin series had not seen any improvement in the non-operated hand had they been submitted to unilateral surgery, and if the 12 patients lost to follow-up had

failed to feel a relief on their non-operated hand after unilateral surgery, the positive clinical impact of unilateral surgery would fall from 58 to 27 % [20]. Heterogeneity of the included patients might also contribute to the observed dispersion of the reported clinical benefits of unilateral carpal tunnel release in patients with bilateral CTS. Previous literature confirms that associated diseases, gender, BMI, age, ethnicity and occupation modify the prevalence and the natural course of CTS [4, 17]. For instance CTS is a rare condition in the non-white South African population and in North America, white US navy personnel have CTS at a rate 2–3 times that of black personnel [12, 14]. In studies comparing the outcomes of unilateral surgery in the context of bilateral disease, the patient populations are diverse: Afshar et al. [1] included only patients with idiopathic CTS, whereas McLaughlin et al. [20] included patients with diabetes mellitus, hypothyroidism, Paget disease, sarcoidosis and hypertension. Iranian women represent the totality of the Afshar series, with 73 % of them working as housewives, whereas our patients are largely of Caucasian origin with a wider professional distribution.

Our data suggests that for patients who suffer from bilateral CTS, unilateral surgery on the most symptomatic side with future assessments on the contralateral hand is a justified option. Although there is some evidence that delayed treatment of CTS might correlate with poorer surgical outcome [10, 16, 22], recent literature has called those findings into question [8]. Some authors advocate simultaneous rather than consecutive bilateral carpal tunnel release as a strategy to decrease the mean total operating room time, clinic visits and time off from work [30]. However, this argument is only valid if it is assumed that all patients with bilateral condition will eventually require bilateral surgery, which contradicts the knowledge that many patients with CTS can be treated non-operatively. The prevalence of clinically certain CTS is 3.8 % in Sweden [4], but Atroshi et al. [3] suggest that only 0.7 % of the Swedish population has symptoms severe enough to require intervention.

One of the principal strengths of our prospective clinical study is the 100 % follow-up rate at 12 months, which eliminates the response bias. This series is comprised of a relatively large number of patients (69) who were evaluated using subjective, clinical and objective data including bilateral pre-operative electrophysiological studies. The timing of follow-up was consistent for all patients. Our study presents several limitations. (1) The follow-up period of 12 months is relatively short. (2) Although bilateral pre-operative electrophysiological studies were performed for all patients for diagnostic purposes, we did not obtain post-operative values to monitor evolution. Our choice was motivated by the relatively invasive nature of electrophysiological studies, combined with the controversy regarding their value in diagnosing CTS and measuring its severity. Although a correlation has been suggested between nerve conduction recovery after surgery and

pre-operative electrophysiological findings [7, 21], some patients with symptomatic CTS with normal median nerve conduction respond favourably to surgery [11, 13, 15]. Conversely, electrophysiology of the median nerve can be perturbed in asymptomatic patients [27]. (3) We established that in our series, gender, age, professional status, duration of pre-operative symptoms and severity of electrophysiological disturbances were not predictors of post-operative results, but we did not examine weight, ethnic origins or comorbidities, or the presence of an associated worker's compensation claim as potential factors of influence. (4) We fail to propose, but hypothesize to explain why symptoms in a non-operated hand improve after surgery on the contralateral hand.

The prevalence of CTS in the general population makes the choices and timing for treatment a relevant issue. Regardless of the reasons for improvement, this study demonstrates that a large proportion of patients feel significant or complete relief in the non-operated hand after contralateral surgical release of carpal tunnel. These results are particularly important when planning treatment for patients with bilateral condition, given the possibility to abstain from a surgery that may be avoided if the patient remains asymptomatic on the non-operative hand. We consequently consider that unilateral surgery followed by further assessments of the contralateral hand is both an economically and therapeutically reasonable strategy.

A large randomized prospective trial comparing the long-term outcome between patients with bilateral CTS operated unilaterally and those operated bilaterally would allow further understanding of the reasons for the improvement in the non-operated hand, the natural course of CTS and predicting factors for evolution.

Conflict of Interest Florence Unno declares that she has no conflict of interest.

Stefano Luchina declares that he has no conflict of interest.

Dominique Bosson declares that he has no conflict of interest.

Cesare Fusetti declares that he has no conflict of interest.

Statement of Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent Informed consent was obtained from all patients for being included in the study.

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