European Journal of Neurology 2003, **10:** 733–736

SHORT COMMUNICATION

Results of carpal tunnel release

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Keywords:
carpal tunnel syndrome follow-up, carpal tunnel release, electrophysiological tests, nerve conduction

Received 29 January 2003
Accepted 27 May 2003

We evaluated, by means of a prospective study, the results of carpal tunnel release both clinically and electrophysiologically in 188 patients with a carpal tunnel syndrome. A questionnaire was completed by patient and surgeon pre- and postoperatively (6 and 12 months after operation), when physical examination, electromyography and nerve conduction tests were also performed. Full pre- and postoperative results were available for 136 patients and 82% of the patients were satisfied with the results of the operation. Symptoms caused by median nerve compression showed the greatest improvement and no fixed patterns with regard to unsatisfactory results were found. If pain persisted in the wrist, many patients considered the operation to have been unsuccessful. Electrophysiological improvement occurred in all patients and at 12 months follow-up, median nerve conduction was normal in 21% of cases. Thus distal sensory latency remained abnormal in 79% of the patients, emphasizing the need for caution when recurrence of carpal tunnel syndrome is diagnosed in such cases.

Introduction

Carpal tunnel syndrome is a common entrapment neuropathy of the median nerve. It is often present in both hands, occurring more frequently in women. Risk factors have been defined by de Krom *et al.* (1990) and Nordstrøm *et al.* (1997). As carpal tunnel syndrome may be regarded as a clinical disorder resulting from compression of the median nerve in the wrist, the diagnosis can usually be made confidently by electrophysiological tests. Since the publication by Learmonth (1933), carpal tunnel syndrome has been treated by severing the transverse carpal ligament. This so-called carpal tunnel release usually relieves symptoms, but occasionally patients complain that the operation has not been sufficiently helpful or they present with symptoms, thought to indicate recurrence. The extent, cause and incidence of this unsatisfactory result are unknown. In an attempt to improve our understanding of such cases, we studied 188 consecutive patients electrophysiologically. It was not our aim to study the cause of these unsatisfactory results, but we wanted to establish the extent of the electrophysiological 'cure' following carpal tunnel release.

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Patients and methods

In this prospective, unselected, consecutive study, 188 patients (188 hands), 146 females and 42 males, were investigated. The ages of the women varied between 21 and 83 years (mean 50 years; SD 13.4) and of the men between 21 and 80 years (mean 44 years; SD 14.2). We are not aware of the presence of a gold standard for the clinical diagnosis of carpal tunnel syndrome, but the criteria reported by Rempel *et al.* (1998) and Rosenbaum (1999) apply to these patients. The conditions for inclusion in the study group were diagnosis of carpal tunnel syndrome on clinical grounds and by nerve conduction studies, and the patient's informed consent to participate.

Questionnaires had to be completed separately by the patient and by a member of the medical staff upon entry into the study pre-operatively and at follow-up 6 and 12 months after surgery. Both electromyography and nerve conduction tests were performed prior to surgery. At follow-up visits, only nerve conduction tests were performed. The questionnaires completed by the medical staff member reported the investigation of the extent of hypoaesthesia, including pin-prick, manual testing of muscle power and record of thenar muscle wasting if present, and on the inspection for the presence or absence of vasomotor disturbances. These items were examined upon intake into the study and at both follow-up visits.

Electrophysiological tests were performed using a Medelec Mystro MS 25 or a Medelec MS 6 (Oxford

Grade	Syndrome	Δ
0	Normal median nerve conduction	0–0.4 ms
1	Marginal carpal tunnel syndrome	0.5–0.7 ms
2	Mild carpal tunnel syndrome	0.8–1.5 ms
3	Moderate carpal tunnel syndrome	> 1.6 ms
4	Severe carpal tunnel syndrome	> 1.6 ms + increased motor latency (> 5.0 ms)
5	Very severe carpal tunnel syndrome	No sensory or motor response

Table 1 Gradation of severity of carpal tunnel syndrome according to difference between distal sensory and motor latencies of median and ulnar nerves (Δ)

Instruments, Medelec, Old Woking, Surrey, UK) in a standardized manner (time base 2 ms; filters between 10 Hz and 2 kHz for sensory nerve conduction studies and between 3 Hz and 10 kHz for motor studies). Tests consisted of sensory and motor nerve conduction studies, and a pre-operative examination of the median nerve-innervated hand muscles. The median nerve was stimulated at the wrist and elbow and the sensory nerve action potentials (SNAPs) were recorded with ring electrodes around digits III and IV. The compound motor action potential (CMAP) of thenar muscles was recorded with surface disc electrodes. The ulnar nerve was stimulated at the wrist. Motor testing was performed orthodromically and sensory testing antidromically. Sensory action potentials were measured in latency and amplitude but only latency was used for gradation of severity. Distal sensory latencies of median and ulnar nerves were compared on the fourth finger while distal motor latencies of these nerves were compared with the responses of the musculus abductor pollicis brevis and the musculus abductor digiti quinti. The carpal tunnel syndrome was graded for severity (White *et al.*, 1988) according to the difference between distal sensory and motor latencies of median and ulnar nerves and the presence or absence of electromyographic disturbances in the intrinsic hand muscles innervated by the median nerve (Table 1). Pathological muscle fibre activity was only found in patients with severe carpal tunnel syndrome. As this finding did not contribute to the gradation of the severity of the neuropathy, these findings have not been reported in this paper. Two patients underwent surgery without pre-operative nerve conduction studies being carried out. Seven patients (4%) were included and operated although their nerve conduction studies were within the limits considered normal. These conduction measurements were performed before this study had started at the time of the operation of their first hand and were not repeated at the time of the operation of the second hand.

All the patients had their transverse carpal ligament completely sectioned by a neurosurgeon through a small longitudinal skin incision in a palmar crease. Immediately following surgery, the patients were stimulated to use their hands as much as possible. External immobilization was not advised.

All questionnaires and electrophysiological data were available for 136 patients. At 6 months follow-up, 31 patients refused post-operative electrophysiological examination and this number increased to 52 patients at 12 months follow-up. We were concerned whether these patients could represent a particular group because of the unsatisfactory relief of their symptoms. Their omission could result in biased conclusions. They were, therefore, interviewed either by letter or by telephone. They were also asked to give their reasons for refusing to undergo repeat testing. The result of these interviews was used to compare this patient group to the patients who had repeat electrophysiological tests. Statistical evaluation, performed by Wilcoxon's matched pairs signed rank test, did not reveal a difference concerning outcome between these groups.

Results

Pre-operatively, nocturnal paraesthesias were present most frequently (91%), while palmar hyperhydrosis was not a prominent symptom (29%) in this series. The degree of relief of these and other signs and symptoms, both 6 and 12 months after operation, is indicated in Table 2. If one includes those patients who were followed up by letter or telephone the clinical results cover a total number of 188 patients.

Six months after the operation, 42 patients (22%) complained of pain in the operated wrist. One year after release, this number had decreased to 10 patients (5%)

Table 2 Frequency (in %) of principal features in the present series prior to surgery and at follow-up

	Before surgery	6 months follow-up	12 months follow-up
Nocturnal paraesthesia	91	15	15
Both diurnal and nocturnal paraesthesia	89	15	16
Pain in hand, arm, shoulder	88	31	33
Subjective numbness of fingers	81	6	12
Sensation of swelling of fingers	74	37	28
Clumsiness	74	24	19
Diminished pinch	74	32	24
Vasomotor disturbance	47	29	15
Palmar hyperhydrosis	29	15	15

Table 3 Classification of patients according to electromyographic gradation of carpal tunnel syndrome before and after operation

Grade	Before surgery ($n = 186$)	6 months follow-up ($n = 155$)	12 months follow-up ($n = 136$)
0	7 (4)	24 (16)	28 (21)
1	26 (14)	33 (21)	33 (24)
2	49 (26)	57 (37)	51 (38)
3	29 (16)	23 (15)	11 (8)
4	35 (19)	10 (6)	11 (8)
5	40 (21)	8 (5)	2 (1)

The values in parentheses are percentages.

but this was a complaint which often influenced post-operative evaluation by these patients.

One year after release, 82% of the patients were fully satisfied with the result, 14% indicated the result was reasonable and 4% were not satisfied. In 15% of the patients, some paraesthesias persisted. There was no relation with the degree of electrophysiological recovery. The changes in temperature, colour and sweating of the palm of the hand, commonly mentioned as autonomic signs of carpal tunnel syndrome showed less improvement. In this series one patient developed sympathetic reflex dystrophy. There were no further complications.

Graded results of electrophysiological tests are presented in Table 3. At 6 months follow-up, 155 patients, and at 12 months follow-up, 136 patients consented to electrophysiological examination. After operation, the metric values from distal sensory and motor latency tests improved in the majority of cases (79 and 96%, respectively, $P = 0.0001$). Both graded and metric results showed a statistically significant improvement. In 21 and 4% the values of distal sensory and motor latency tests remained unchanged, respectively. Deterioration did not occur. Twelve months after release, nerve conduction slowing in the median nerve was still found to be present in 79%. Thus normal conduction velocity returned in this series in one of five treated patients. There was no statistical relation between the degree of clinical relief and that of improvement of nerve conduction. Also there was no correlation between the pre-operative neurophysiological grade and the satisfaction of the patients at 12 months follow-up.

Discussion

The prevalence of treated and untreated carpal tunnel syndrome in women in The Netherlands is 3.4 and 5.8%, respectively, thus making an overall prevalence of 9.2%. In men it appears to be low (de Krom *et al.*, 1992), the female:male ratio in our study being 3.5:1.

In 1966, a large study of post-operative results was completed by Cseuz *et al.* (1966), who found improvement of signs and symptoms in a large number of the cases. In 1989, de Krom reported high success rates in patients with more severely disturbed sensory nerve conduction velocities of the median nerve at the wrist, in young patients, in left-handed patients who underwent surgery for left-sided carpal tunnel syndrome and in patients who had daily symptoms prior to operation. After a systematic review of randomized trials, Gerritsen *et al.* (2001) concluded that standard open carpal tunnel release is the preferred method of treatment.

As far as we are aware, the type of systematic prospective follow-up of distal sensory latency carried out in this study is not available in the literature. The results of small retrospective series mostly show reports on follow-up of distal motor latency (Schlagenhauff and Glasauer, 1971; Mühlau *et al.*, 1984). In a partial retrospective and prospective study of 16 patients, Finestone *et al.* (1996) analysed the results of improvement in distal motor and sensory latencies; the latencies did not normalize in their series.

In the literature, unsatisfactory results are attributed to surgical consequences (Netscher *et al.*, 1997), to complications (MacDonald *et al.*, 1978) or to recurrence (Stark, 1968; Langloh and Linscheid, 1972; MacDonald *et al.*, 1978) of the carpal tunnel syndrome, or to an incorrect pre-operative diagnosis (Kulick, 1996).

Recurrent carpal tunnel syndrome has to be defined as the return of signs and symptoms, which can be explained by entrapment of the median nerve and proven electrophysiologically by a decrease in nerve conduction velocities compared to earlier post-operative measurements. In the literature, data on recurrent carpal tunnel syndrome are scarce and conflicting. This may be related to complications during surgery such as nerve lesions during release, infection, and haemorrhage from an accessory median artery (MacDonald *et al.*, 1978) and sympathetic reflex dystrophy (Stark, 1968; MacDonald *et al.*, 1978). Aberrant innervation of the hand can be misleading, but this must be diagnosed by thorough pre-operative electrophysiological tests. Other conditions which can lead to an incorrect diagnosis, are radiculopathy of the C7-root, thoracic outlet syndrome (Schnyder *et al.*, 1994), polyneuropathy, cervical myelopathy and cerebral sensory disturbances.

It is not clear whether a recurrence of carpal tunnel syndrome can occur when release has been performed by complete section of the transverse carpal ligament in patients in whom the diagnosis of carpal tunnel syndrome was correct. Langloh and Linscheid (1972) have attributed recurrence in such cases to scar formation in the carpal tunnel, but in our opinion this is not a sufficient explanation for a recurrence. In any event a recurrence must be confirmed by electrophysiological

tests. Studies in which pre- and post-operative evaluations have been performed have indicated that distal latencies of the median nerve improve, but frequently do not return to normal (Schlagenhauff and Glasauer, 1971; Mühlau *et al*., 1984; de Krom, 1989; Nolan *et al*., 1992; Finestone *et al*., 1996). In our prospective study, cases with severe delay of latencies also recovered partially, even after prolonged follow-up. It is evident that in these patients, in the case of an unsatisfactory result, a recurrent carpal tunnel syndrome can be diagnosed incorrectly if one is relying on one electrodiagnostic study only. A recurrent carpal tunnel syndrome can only be diagnosed reliably if repeated post-operative nerve conduction studies demonstrate progression of the conduction abnormality. Thus the diagnosis of recurrent carpal tunnel syndrome may be delayed. Magnetic resonance imaging (MRI) is as yet of limited help in supporting the diagnosis (Pierre-Jerome *et al*., 1997; Fleckenstein and Wolfe, 2002).

Conclusion

In 15% of the patients with carpal tunnel syndrome, some paraesthesias remain in the hand after carpal tunnel release. Pain in the wrist and arm often persists for a long time. If such features are regarded as recurrent carpal tunnel syndrome, this can be incorrectly verified by electrophysiological tests, because electrophysiological 'cure' after carpal tunnel release occurs in a minority of cases only. Recurrent carpal tunnel syndrome can only be confirmed by deterioration of the post-operative electromyographic and/or nerve conduction findings.

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