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Ultrasonographic and functional changes of the ulnar nerve at Guyon's canal after carpal tunnel release

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ABSTRACT

Objective: To describe morphologic and functional modifications of the ulnar nerve at the wrist in carpal tunnel syndrome (CTS) after carpal tunnel release (CTR).
Methods: Ultrasonography was used to study the cross sectional area (CSA) of the ulnar nerve at Guyon's canal, before and 1 and 6 months after CTR, in 18 CTS patients. A parallel electrophysiological and clinical analysis was also conducted.
Results: CSA of the ulnar nerve significantly increased 6 months after CTR. Ten (55%) cases showed abnormal CSA values compared to a control group before surgery and five (28%) at 6 month follow-up. In addition, there were improvements in the motor and sensory ulnar axon recruitment properties and the conduction values in sensory ulnar fibres. Patients with extra-median distribution of paresthesia (4 subjects) were free from symptoms.
Conclusions: CTR has a significant effect not only on the anatomical geometry of Guyon's canal, but also on the morphology and function of the ulnar nerve.
Significance: In CTS, high pressure in the carpal tunnel may result in anatomical changes of ulnar nerve, thus causing functional impairment to the ulnar fibres. CTR appears to reverse some of this damage.

1. Introduction

There is close anatomical contiguity between the carpal tunnel and Guyon's canal. The transverse ligament forms the roof of the carpal tunnel as well as the floor of Guyon's canal, so that volumetric changes in one channel can easily be reflected in the other. Indeed, a volumetric increase with decreased pressure in Guyon's canal has been described in patients with carpal tunnel syndrome (CTS) after carpal tunnel release (CTR) (Ablove et al., 1994, 1996; Okutsu et al., 2009). In addition, by magnetic resonance imaging, Richman et al. (1989) showed prominent differences in the shape of Guyon's canal after CTR in CTS: before surgical treatment the canal was a flattened triangle, while after CTR, it changed to oval, with its longest dimension in the palmar–dorsal direction.

Although these changes can affect the ulnar nerve, there are no previous prospective studies on this topic. Morphologic changes of the ulnar nerve are of particular interest, since there is evidence of conduction failure in some ulnar axons in CTS patients (Ginanneschi et al., 2007, 2008a). The hypothesis that ulnar conduction changes in CTS patients, rather than simple comorbility, are due to mechanical distortion of the Guyon's canal as a consequence of the high pressure in the carpal tunnel of CTS patients, needs to be seriously considered. (Ginanneschi et al., 2008b). In the present study, ultrasonography (US) was used to study the cross sectional area (CSA) of the ulnar nerve at Guyon's canal before and 1 and 6 months after CTR in 18 CTS patients. A parallel electrophysiological and clinical analysis was also conducted.

2. Patients and methods

2.1. Diagnostic criteria and patient selection

A prospective study was carried out on 18 hands belonging to 18 patients (mean age 51.6 ± 11 range 28–67, 15 women, 3 men)

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with CTS who underwent surgical release by the same neurosurgeon. All patients referred to the outpatient department of Neurosurgery of Siena between 10 January 2007 and 31 May 2007. The diagnosis of CTS was made by the surgeon according to the criteria of the American Association of Electrodiagnostic Medicine (1993). The criteria include clinical history and neurographic evidence of slowing of distal median nerve conduction velocity. Clinical symptoms included any paresthesias or pain in all or part of the hand innervated by the median nerve. It was a consecutive sample, including about 22% of all CTS hands operated by the surgeon in that period. We excluded CTS patients over 70 years in order to avoid subjects with age-related neuropathies (20 subjects), CTS patients with diabetes (10 subjects), CTS patients with polyneuropathy and other neurological disease (15 subjects) and CTS patients with a history or clinical signs suggesting systemic disease (10 subjects). Finally five CTS patients declined to participate in the study and two were lost to follow-up.

In order to obtain control values of the ulnar nerve CSA at Guyon's canal, we enrolled 14 healthy volunteers (12 women, 2 men; mean age 48 ± 8.9 years, 30–70 range).

2.2. Study protocol

The surgery consisted of an open technique involving a mini-incision of the palm, reported in detail elsewhere (Reale et al., 2003). All subjects gave their informed consent to participation in the study.

The study protocol included clinical examination, subjective complaints evaluation, electrophysiological and US evaluations before surgery and at 1 and 6 months after surgery.

The clinical severity of CTS patients was evaluated with a five-point ordinal historical-objective (Hi-Ob) scale (Giannini et al., 2002). None of the patients' hands showed weakness and atrophy of the intrinsic muscle supplied by the ulnar nerve. We asked patients whether paresthesias were diffuse in the hand (fingers, dorsal and palmar region of the hand) or localised in certain fingers. If localised in certain fingers, the patient had to name the fingers with paresthesias.

A neurophysiological examination, including neurography of the median, radial and ulnar nerves was performed by the same neurophysiologist on the same day of the CTR, in line with the guidelines of the American Association of Electrodiagnostic Medicine (2002). The details are reported in a previous study (Ginanneschi et al., 2007). In particular, electrodiagnostic evaluation was conducted to exclude ulnar neuropathy at the elbow, according to the published practice parameter guidelines (AAEM, 1999). When the subjects' symptoms spread out the territory of the median nerve to that of the ulnar nerve, other tests were performed to exclude outlet syndrome, lower trunk brachial plexopathy, C8-T1 radiculopathy (performing other appropriate electrodiagnostic tests, or, if necessary, MRI of cervical spine) and polyneuropathy (performing motor conduction velocity of the deep peroneal nerve and sensory conduction velocity (SCV) of the sural nerve). The skin temperature of the hand was kept constantly above 32 °C with an infrared lamp. A scale of electrophysiological severity of CTS was used for the statistical analysis, with stages from 1 to 5. This scale evaluates the presence/absence of sensory action potential (SAP) and compound muscle action potential (CMAP) and normal/abnormal SCV and distal motor latency (Padua et al., 1997).

Finally, recruitment properties of the ulnar nerve were studied by analysing the relationship between the intensity of electrical stimulation and the size of motor and sensory responses, i.e., the input–output curve (I–O curve). This technique can be used to study groups of patients or individual patients. In order to determine the relationship between the intensity of electrical stimulation and the size of the ulnar nerve motor response, the stimulating electrode was initially placed over the wrist, and its position adjusted until the site with the lowest threshold for eliciting a CMAP of 0.1 mV (baseline-negative peak) was established. In order to determine ulnar nerve SAP amplitude (SAPa), we used the threshold that produced a SAPa of 1 μV; all sensory responses were averaged. Stimulus intensities were increased in steps of 0.2 mA until the maximum (motor and sensory)-wave was obtained. I–O relationship data was fitted to a Boltzmann sigmoidal function by the Lavenberg–Marquard non-linear least-mean-square algorithm (Press et al., 1986). Recruitment curves were constructed by normalizing stimulus currents and response amplitudes. This enabled comparison of individual I–O relationships. Parameters of the curves obtained before CTR were compared with those obtained 1 and 6 months after surgery.

A high-resolution sonographic examination of the ulnar nerve in the Guyon canal was performed by the same rheumatologist, experienced in musculoskeletal US, on the same day before the surgical release. A real-time scanner (Esaote Technos Mp) with a 5–10 MHz linear array transducer was used. Patients were seated in a chair with their arms extended, hands resting in a horizontal supine position on the examination couch and finger semi extended. At Guyon's canal, the examiner could easily visualise the ulnar nerve lying between the pisiform bone and the ulnar artery. The longitudinal views has been obtained to follow the nerve along the entire length. The CSA of the nerve was measured on transverse plane by manual tracing at the internal rim of the hyperechogenic line that defines the nerves margin (perineurium), similar to the technique used for the median nerve (Mondelli et al., 2008a). The weight of the probe was applied without additional pressure. At every ultrasonographic evaluation, three consecutive measurements were taken of the ulnar nerve at the level of the pisiform bone, and the largest one was considered for statistical analysis. The intraobserver reliability for nerve measurement has been tested previously and published elsewhere (Mondelli et al., 2008a).

2.3. Statistical analysis

The values in the three groups (before, 1 and 6 months after surgery), were compared using the non-parametric Friedman test. If comparison of the groups showed a significant difference, Dunn's multiple comparison test was performed. The data is reported as median and interquartile range (IQR). We used Mann–Whitney test to evaluate differences in CSA between CTS patients and controls. The limits of the CSA values of control subjects were defined from the percentile divisions: 2.5th and 97.5th percentiles.

The score of the Hi-Ob and electrophysiological severity scales were considered to be normalised if the value = 0 and to have improved or worsened if their values at the follow-ups differed from the baseline values by at least one stage.

Correlations between the electrophysiological parameters and the CSA values of the ulnar nerve were tested with the Spearman correlation coefficient.

3. Results

The outcome of all operations was good and there were no complications. No patients reported a worsened situation after CTR. Table 1 shows the clinical and electrophysiological severity scores, the neurographic findings of the median, radial and ulnar nerves (means, SD) before and 1 and 6 months after CTR, and the statistical differences.

In our sample, 14 (78%) of all patients had paresthesias in median-innervated parts of the hand (median distribution), whereas in 4 (22%) the symptoms spread out of the median territory; in particular, in 3 cases the paresthesias included all fingers plus the dorsal