Foot and Ankle Surgery 20 (2014) 109–114

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Contribution of a new electrophysiologic test to Morton's neuroma diagnosis

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ARTICLE INFO

Article history:
Received 1 August 2013
Received in revised form 3 December 2013
Accepted 23 December 2013

Keywords:
Morton's neuroma
Electrophysiology
Electroneurography
Metatarsalgia
Forefoot pain

ABSTRACT

Background: Morton's neuroma causes metatarsalgia due to the interdigital neuropathy. The small nerve diameter compromises their evaluation in image studies. To overcome this problem we propose a new electrophysiological test.
Methods: We conducted a prospective case–control study performing a orthodromic electroneurography using subdermal electrodes in controls and patients to assess the validity. Additionally all patients were tested with magnetic resonance. Some patients required surgery and subsequent histological evaluation.
Results: The new ENG procedure showed higher sensitivity and specificity. Methodological standardization was easy and the test was well tolerated by the subjects.
Conclusions: Our test demonstrated remarkable diagnostic efficiency, and also was able to identify symptomatic patients undetected by magnetic resonance, which underlines the lack of correlation between the size and intensity of the lesion. This new electrophysiological method appears to be a highly sensitivity, well-tolerated, simple and low-cost for Morton's neuroma diagnosis.

1. Introduction

Morton's neuroma (MN) is a mononeuropathy [1] frequently causing forefoot pain or metatarsalgia (MA) [2]. MN results from the focal fibrous thickening of any of the interdigital nerve (IDN) branches, most commonly of the II and III intermetatarsal spaces between the metatarsal (MT) heads. The lesion mechanism is complex and it is generally initiated when the IDN is overstretched by forced pronation and metatarsophalangeal (MTP) joint hyperextension. This is characteristic of nonorthopedic positions such as wearing high-heeled shoes [3]. This process is likelier to happen in the IDN III due to the greater mobility of MT IV and V, together with the relative steadiness of the IDN I, II and III, the general anatomical anchoring of all IDN to the deep transverse metatarsal ligament and the adhesion phenomena appearing in the intrametatarsal spaces. Regardless of the mechanisms involved, the IDN suffers chronic progressive damage in the myelin sheath and axons leading to intra-perineural fibrosis, vascular proliferation, edema and axonal degeneration–regeneration. These regeneration processes are often anomalous, provoking the swelling of the nerve in a narrow rigid anatomical location, which results in blood vessel compression and chronic ischemia. Axons become dysfunctional, probably showing diminished excitatory thresholds, which would explain the predominantly positive symptoms.

MN diagnosis is based on clinical history and exploratory signs [3,4]. This neuropathy is characterized by anterior plantar pain in both interdigital spaces (IDS) and the MTP joint. Frequently, the pain also radiates to the toes and it is exacerbated by bipedestation and walking. Mulder's sign is a very characteristic finding, consisting in a "click" (that can be felt or even heard), accompanied by an intensification of the plantar pain that can be produced by squeezing the foot side to side and selectively putting pressure in the affected space.

Normal IDN diameters are no more than 2 mm wide [5–7], which makes image MN diagnosis difficult. Magnetic resonance (MR) is considered a sensitive and specific diagnostic technique as long as the IDN diameter is wider than 5 mm [3,6,8]. Some authors claim that the symptomatology appears when the MN size is over 5 mm. However, the available pathological evidence added to the fact that many MN cannot be diagnosed by MR [9–11] do not support that view. Rather, it seems likely that a significant number

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http://dx.doi.org/10.1016/j.fas.2013.12.006
1268-7731/

of MNs do not reach that presumed critical diameter width and nevertheless cause the symptomatic picture. Thus, the size of the MN and the intensity of the symptoms do not seem to have a positive correlation [12]. The high-resolution ultrasonography (HRUS) is a common diagnostic technique of high value for the morphological assessment of soft tissue structures, such as MN. However, HRUS – similarly to MR – also shows varying results due to the aforementioned lack of correlation between size and symptomatology in MN [6,13]. Besides, HRUS presents the limitation of relying largely on the experience of the observer. Nevertheless, some authors such as [14] estimated a higher than 91% sensitivity, close to 100% specificity, 100% positive predictive value and 20% negative predictive value for HRUS in MN. Other authors cite even higher sensitivity and specificity values for HRUS [5,15,16]. Our experience with the use of HRUS does not confirm such an optimistic outcome and perhaps certain caution is advisable. Nonetheless, HRUS shows reasonably good sensitivity, low cost and high tolerance, representing a valuable test that should be incorporated to routinary diagnosis of MN.

The electroneurography (ENG) is generally considered a useful, although laborious diagnostic technique because it is usually based on "near nerve" studies [17–20] due to the deep anatomical location and small size of the IDN, that may elicit a certain level of intolerance from the patients. However, ENG is a sensitive and particularly specific test. In this work, we present a comparative MN diagnosis study between MR and the modified ENG procedure we propose, in the context of the current literature in the field.

2. Methods

2.1. Patients and controls

38 feet corresponding to 28 MN patients (34 from women + 4 from men; mean age: 46.2 years; range: 20–71) and 30 feet from 28 control subjects (27 women + 1 man; mean age: 48, range: 29–71) coming from the Departments of Traumatology, Rehabilitation, Dermatology and Rheumatology were studied during 2008. After careful examination by foot and ankle expert surgeons from the Department of Traumatology, 28 feet from the patient group were found to fulfill the diagnostic criteria for MN: selective or predominant pain with plantar stepping and forefoot walking, painful dysesthesias or paresthesias, and positive Mulder's sign in one or more IDSs [3,4]. All feet underwent neurological exploration and neurophysiological evaluation. For the latter, we included sensitive orthodromic ENG using subdermal electrodes overlying medial and lateral plantar nerves, sensitive antidromic ENG overlaying sural and peroneal superficial nerves and motor ENG on tibial posterior and peroneal nerves. EMG using coaxial needles was performed on *vastus medialis*, *rectus femoris*, *tibialis anterior* and *medialis* and *lateralis gastrocnemius* muscles. 19 MN were on the right side, 19 on the left side and 14 were bilateral. In 13 of the MN, the symptoms occurred in one IDS; in 19, MN appeared in 2 IDS and in 3, MN in 3 or more IDS.

Patients with clinical and electrophysiological criteria for polyneuropathy, lumbosacral radiculopathy, plexopathy or other monoenuropathies (peroneal neuropathy, posterior tarsal tunnel syndrome, pyramidal syndrome or sciatic neuropathy in any segment) were excluded from the study.

Both patients and controls received clinical examination, lateral and postero-anterior foot radiography and electrophysiological evaluation. Patients also received MR evaluation for the affected foot. All participants were appropriately informed and signed the corresponding informed consent.

2.2. Methods

Electrophysiological studies were performed using a SynergyR electromyograph (Carefusion USA). 20 Hz to 2 kHz filters, 10 μV/div gain, 20 ms scan time and 0.2 ms pulse duration stimulus were used for sensitive ENG. For motor ENG, 20 Hz to 5 kHz filters, 2 mV/div gain, 10–20 ms scan time and 0.5 ms pulse duration stimulus were employed.

For interdigital stimulation, bipolar ring electrodes were placed at each IDS (Fig. 1) 20 mm away from each other (in the smaller feet they were a little closer, but always more than 10 mm away), interposing non-conductive material (cotton or gauze) between the cathode and the anode. All IDS were thoroughly cleaned to improve conductivity. The stimulus intensity was never higher then 20 mA (3 times the subjective threshold). The resistance always remained below 10 MΩ. Orthodromic ENG studies of the lateral and medial plantar nerves were performed, typically using 12 mm long subdermal needles (17 mm long needles were employed for patients with edemas or significant obesity) placed perpendicularly in relation to the surface of the foot. One of them

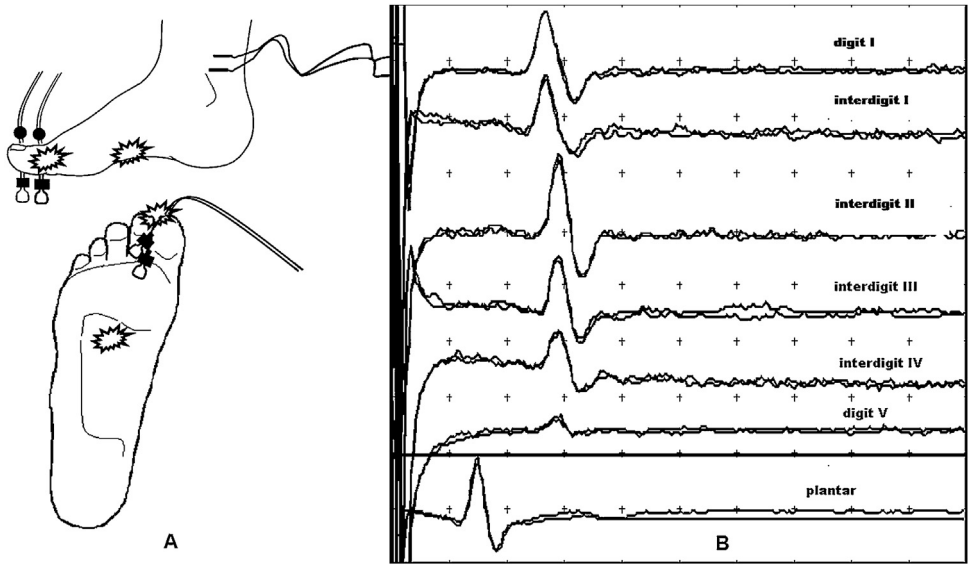

Fig. 1. (A) Schematic drawing showing the placement of the stimulating bipolar ring electrodes. (B) Examples of sensory evoked potential (SEP) graphs in the control group.