

Peripheral Repetitive Magnetic Stimulation: A Novel Approach for Hand Rehabilitation in Carpal Tunnel Syndrome – A Pilot Study

Savulescu Simona Elena, Grozoiu Lavinia, Popa Florina, Dumitru Luminita, and Berceanu Mihai

Abstract—Carpal tunnel syndrome is one of the disabling conditions that affects human participation and quality of life. The surgical treatment of diagnosed carpal tunnel syndrome is well known to be more effective than the conservative methods, but this pilot study on five subjects diagnosed with carpal tunnel syndrome gives hope that repetitive magnetic stimulation applied to the wrist could be effective in the rehabilitation of the hand neuro-muscular functionality and symptomatology. The goal of this study was to evaluate the short and medium effects of peripheral repetitive magnetic stimulation (RMS) on carpal tunnel pain and hand's loss of function. Two weeks of daily sessions treatment, each lasting 10 minutes of stimulation, have shown significant improvement of the functional score (Boston Questionnaire), hand grip force and also of symptomatic status (Boston Questionnaire, PainDetect Questionnaire).

Index Terms—Peripheral repetitive magnetic stimulation, carpal tunnel syndrome, rehabilitation, hand grip.

I. INTRODUCTION

Carpal tunnel syndrome is one of the disabling conditions that affect human participation and quality of life. It is the most common of all entrapment neuropathies [1] and it means that the median nerve is compressed within the carpal tunnel. The median nerve is a mixed nerve so we have sensitive and motor symptoms. Depending on the degree of the compression, the lesion of the nerve can be minor, consisting in demyelination, or it can be more severe when axonal impingement occurs. The patient presents with numbness in the first 3 fingers, pain located at the wrist typically at night and sometimes reports the loss of hand grip force.

The diagnosis of carpal tunnel syndrome can be a clinical one, when patient relates the specific symptoms and have Tinel or Phalen signs positive, but most relevant are the

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Simona Elena Savulescu is with the Rehabilitation Medicine Department of Elias University Hospital, 17 Marasti Bd, Bucharest, Romania (PC 011461) (e-mail: simona.manoila@yahoo.com).

Lavinia Grozoiu is with the Rehabilitation Medicine Department of Elias University Hospital, Bucharest, Romania (PC 011461) (e-mail: laviniagrozoiu@gmail.com).

Florina Popa is with University of Medicine, Lucian Blaga, Sibiu, Romania.

Dumitru Luminita and Berceanu Mihai are with Carol Davila University of Medicine and Pharmacy, Bucharest, Romania (e-mail: lumivd@yahoo.com, mberceanu@gmail.com).

electrophysiological findings. An EMG (electromyography) and NCS (nerve conduction study) must be done to every patient in order to exclude a radiculopathy or a double crush syndrome. The specific NCS findings in carpal tunnel syndrome are: prolonged distal latencies, small SNAP (sensitive nerve action potential) and CMAP (compound muscle action potential) amplitudes or decreased sensitive or motor conduction velocities. At the needle detection examination, if there is an axonal loss, the spontaneous activity consisting in PSW (Positive Short Waves) and fibrillation can be found, and also neurogenic MUAP (motor unit action potential). At maximum contraction the pattern of recruitment

is simple or intermediate [2]. Conservative treatment may include corticoid injection, physical therapy (kinotherapy, ultrasound, laser), bracing and alternative therapies. While surgery is known to be the definitive treatment for CTS, some people symptoms improve spontaneously and this may relate to activity daily living modification [1]. Many publications about CTS surgical treatment report excellent results and low complication rates [3]-[5], while others report many kind of complications, such as the recurrence of the carpal tunnel syndrome [6]-[8]. Peripheral nerve repetitive magnetic stimulation might be a new physical agent that can be used to relieve pain and to recover hand function. It is an easy to use comfortable method for the patient in order to obtain nerve stimulation. Based on the principles enunciated in the Gate Control Hypothesis that was published in 1968, stimulation-produced analgesia (SPA) has been a subject to intensive laboratory and clinical investigation [8]. Repetitive magnetic stimulation at the periphery (PRMS), i.e. over spinal roots, nerves or muscles, represents a new painless and noninvasive approach that can contribute to motor recovery [10].

The main objectives in hand neurorehabilitation is to regain sensibility and muscle force, to relieve pain in order to restore hand grip and function. RMS is lately known to have positive therapeutic effects on myofascial pain both short and medium-term [11]. It's also known that a single session of RMS resulted in significant improvement of pain associated with lumbar spondylosis in a randomized, double-blind, placebo-controlled setting [12].

II. OBJECTIVE

The Objective of this pilot study is to determine if peripheral repetitive magnetic stimulation located at the wrist has an impact on nerve regeneration and clinical improvement of hand symptomatology and functionality.

The study is designed to see if there are some perspectives for the treatment with high power magnetic stimulator and a further study is designed to compare the result with those from a control group that will be treated with a Sham coil, but also with the results from a group treated with steroid injection.

III. MATERIAL

The pilot study was done on a group of 5 patients with a clinical reference of carpal tunnel syndrome, one of them with the right hand affected and the rest of them with the left hand affected.

In order to obtain a good diagnostic we also used Boston Questionnaire, a hand grip dynamometer and an electromyography. For the treatment we used a *MagVenture MagPro X100* stimulator with a RT-120 racetrack coil. *Boston Questionnaire* is designed to be applied in patients with carpal tunnel syndrome, with the purpose of evaluating the severity of symptoms (Severity of symptoms-SS) and the degree of manual skill (Functional Status-FS) [13]. *Electromyography*: We Used a Nicolet Compact Meridian. The NCS were done with surface electrodes and the detection EMG was done using a 50 mm × 26 g needle. *The Dynamometer* we used is KERN MAP Version 11. 06/2010 *Pain Detect Questionnaire* is known to evaluate the neuropathic pain and contains questions about the subjective perception of pain, but also objective clinical findings.

IV. METHOD

The group of 5 patients were clinically diagnosed with carpal tunnel syndrome and they were referred to an EMG test. After having the consent of information signed, they were recruited to the study (T1), they have been EMG tested, the hand grip force was tested with the dynamometer (also the healthy hand) and Boston Questionnaire, PainDetect Questionnaire were administered. Each of them had 10 sessions of RMS with the coil located at the wrist. The magnetic stimulation protocol consisted in 100 trains of 5 pulses/train, delivered at 10 Hz, at an interval of 5 seconds between trains. At the beginning and at the end of every session the grip force was tested using the hand grip dynamometer.

The protocol of EMG test included NCS on median nerve consisting in: the latencies of Snap and Cmap, the amplitude of Snap and Cmap, SNCV (Sensitive Nerve Conduction Velocity) and the needle detection examining the spontaneous activity registered from APB (Abductor Policis Brevis) muscle, MUAP analysis and the pattern of interference at the maximum contraction. We consent that if there was no spontaneous activity it will be noted as „0” and if it’s present it will be noted as "1". Likewise it was consented that if the morphology of MUAP is normal it will be noted as "0", between 3-4 phases, crenelation or satellite potentials = 1, 5-6 phases = 2 and more than 7 phases = 3.

Maximum force contraction is noted 3 if it is an interference pattern, 2 if it’s intermediar and 1 if it is a simple one.

At the end of the 10 sessions (T10) they also have been

EMG tested, hand grip force tested and the two questionnaires have been administrated.

Even if the Boston Questionnaire is a self administrated test, we wanted to personally question the patients in order to eliminate the subjective errors.

V. RESULTS

A. The EMG Findings

A significant improvement of SNCV was observed at only one patient (from 28 to 38 m/s), two of them had a minor improve of SNCV From 32, respectively 31 to 35, respectively 36 m/s) and two patient had no modification of the sensitive conduction velocity. No major good results in Cmap latencies was detected (improvements of 0.3 m/s) and the prolonged Cmap latencie registred from one patient can be due to an error of distance measurement from the point of stimulation to the registration electrode.

No significant improvement of Cmap or Snap amplitude was observed after the RMS of median nerve at the wrist meaning that the number of healthy axons of injured median nerve is not recovering (growing). The results show no influence of RMS on SPA recorded from APB muscle except one case of remiting SPA.

Concerning the MUAP morphology, in 3 cases it was observed the new poliphasic morphology of MUAP, one case showed an increased number of phases and one showed no improved poliphasy. Maximal contraction pattern was improved in two cases and the rest showed the same level (see Table I-Table II).

TABLE I: THE VARIATION OF THE SNCV AND CMAP LATENCIES BEFORE AND AFTER THE TREATMENT

Patient	SNCV (m/s) T1	SNCV (m/s) T10	Cmap Latency(ms) T1	Cmap Latency(ms) T10
1	31	31	5.4	5
2	30	30	7.2	7.7
3	28	38	7.3	7.2
4	32	35	4.8	4.8
5	31	36	5	4.4

TABLE II: THE VARIATION OF THE AMPLITUDE OF SNAP AND CMAP BEFORE AND AFTER TREATMENT

Patient	Snap Amplitude (μV) -T1	Snap Amplitude (μV) -T10	Cmap Amplitude (mV) -T1	Cmap Amplitude (mV) -T10
1	10.5	12.6	6.16	5.8
2	1.06	1	9.9	8.7
3	12.9	12.1	7.3	8.6
4	4.17	4.2	0.28	0.3
5	5.57	5.88	3.88	3.92

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B. The Hand Grip Force Results

All the patients had a significant improvement in hand grip force at the end of all ten RMS sessions (with 6 Kg, in average). The last patient had a complete recovery of hand grip force (compared with the healthy hand) (see Table III).

TABLE III: THE HAND GRIP FORCE VARIATION BEFORE AND AFTER THE TREATMENT

Patient	Hand Grip Force (Kg) T1	Hand Grip Force (Kg) T10
1	21.3	25.1
2	14.9	23.9
3	15	23.4
4	10.5	19.5
5	32	39.1

C. The Boston Questionnaire Results

The normal value for the SS and FS score in a healthy patient is 1. All the patients had a better SS and FS score and further studies with a larger number of patients must be done to determine if there is statistic semnificative improvement of symptoms and functional status (see Table IV).

TABLE IV: THE VARIATION OF BOSTON QUESTIONNAIRE RESULTS (SS= SEVERITY OF SYMPTOMS, FS = FUNCTIONAL STATUS) BEFORE AND AFTER THE TREATMENT.

Patient	SS T1	SS T10	FS T1	FS T10
1	3.18	1.81	3	2.14
2	3.09	1.54	3.14	2.14
3	3	2.54	2.75	2
4	3.1	2.2	3.2	2
5	2.45	1.81	2.14	1.28

D. The Pain Detect Questionnaire Results

All the Patients registered a dropp of the score meaning that the pain and numbness were improved but did not disappear (variations of 5 points in average) (see Table V).

TABLE V: THE VARIATION OF PAIN DETECT QUESTIONNAIRE RESULTS BEFORE AND AFTER THE TREATMENT

Patient	Score T1	Score T10
1	16	10
2	16	11
3	6	4
4	9	7
5	12	6

VI. DISCUSSION

The EMG findings were not very encouraging. Some minor improvements of NCS of median nerve at the carpal tunnel level were observed, especially concerning the sensitive nerve conduction velocity with no significant Snap or Cmap increased amplitude but it was observed an enhanced poliphasism at the end of the 10 sessions concurrent with a richer pattern of recrutation at some patients when developing maximum force contraction.

The 5th patient had the best results at EMG studies, questionnaire scores and hand grip force after the treatment showing maybe a better result in acute stages of carpal tunnel syndome(the patient had acute denervation and minor hand grip force loss at the begining of the treatment).

It is not known if the poliphasic MUAP is due to the regeneration of the nerve or if it's consecutive to reconstruction of motor unit because of collateral sprouting. More feasible is the second theory in accordance with the enhanced muscle force and with a better interference patern .

A better result was determined concerning the Boston questionnaire score at the end of the treatment . All the pacients had a drop of the symptome score and functional score meaning the improvement of the sensation and function of the hand.

Consistent with BQ result (SS-score) was also the PainDetect Questionnaire score, which means that RMS has a fast, good effect on patient's symptoms (pain and numbness).

An enhanced hand grip force and function of the hand derives from the drop of functional score and the better force value measured with the dynamometer at the end of the 10 sessions.

VII. CONCLUSION

These preliminar results show that median nerve repetitive magnetic stimulation could be a helpful tool in the neurorehabilitation of carpal tunnel syndrome and a further study is designed to compare the effects of RMS in neurorehabilitation with sham and with the effects of steroid injection.

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Simona Savulescu was born in Tirgu-Jiu in 1981. She obtained her bachelor degree in general medicine from U.M.F Carol Davila Bucharest, Romania, in 2007 then made the residency until 2012 in the Department of Rehabilitation Medicine of Elias University Hospital and since 2011 is a Ph.D student in Medical Science at U.M.F Carol Davila Bucharest, Romania.

She is a consultant physician in the Rehabilitation Medicine Department of Elias University Hospital, Bucharest, Romania since 2012. She is also the electro physiologist of the Department with a high interest in magnetic field therapy.

Dr. Simona Savulescu is an active member of Romanian Society of Rehabilitation, International Society of Physical and Rehabilitation Medicine and of Romanian Society of Electro Diagnostic Neurophysiology.

Lavinia Grozoiu was born in Moreni, Romania in 1984. She obtain her bachelor degree in general medicine from the Transilvania University of Medicine, Brasov, Romania, in 2008. After her residency training in Bucharest, she conducted an 8 month internship in Berlin, Germany.

She is currently pursuing her study for PhD degree in medical rehabilitation, at Carol Davila University of Medicine and Pharmacy Bucharest in collaboration with Medical Park Berlin Humboldtstraße, Charite-University Medicine Berlin. Her research interests include stroke rehabilitation and repetitive magnetic stimulation.

Dr. Lavinia Grozoiu is a member of Romanian Society of Rehabilitation

Luminita Dumitru was born in Draganesti Olt on December 30, 1968. He obtained her bachelor degree in general medicine in 1993 from U.M.F Carol Davila Bucharest, Romania, became in 2002 a consultant physician at Colentina Hospital, Bucharest, in 2004 a second consultant at Elias University. Since 2006 she is an assistant professor at U.M.F Carol Davila Bucharest, Romania and a Ph.D from 2014 in the Rehabilitation Medicine Field.

She is a second consultant physician since 2004 at Elias University Hospital, Bucharest, Romania.

One of the major field of her research interest is the electrotherapy and its effects on heart rhythm disorders.

Asst. Prof. Dr. Luminita Dumitru is an active member of Romanian Society of Rehabilitation, International Society of Physical and Rehabilitation Medicine.

Mihai Berceanu was born in Bucharest, Romania in 1962. He obtained his bachelor degree in general medicine from the Carol Davila University of Medicine and Pharmacy, Bucharest, in 1987. After his residency training in Romania, he performed multiple internships abroad (Bruxelles 1997, Berlin 1998, Washington 2000, Winterthur 2004, Innsbruck 2006). He completed his PhD degree in field of rehabilitation using electromyography biofeedback, in 2013. He is now a professor of Rehabilitation Medicine at the Carol Davila University.

He is now the head of The Rehabilitation Medicine Department from Elias University Hospital Bucarest, Romania. He has numerous publications in international journals and became a professor of Rehabilitation at the Carol Davila University.

Prof. Dr. Mihai Berceanu is a member of the European Board and AAPM&R since 2005. He is also a member of World Federation of Neurological Rehabilitation, ISPRM, GESET.