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PERIPHERAL APPLICATION OF REPETITIVE PULSE MAGNETIC STIMULATION ON JOINT CONTRACTURE FOR MOBILITY RESTORATION: CONTROLLED RANDOMIZED STUDY

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ABSTRACT

Background: Joint contracture is a limitation in the passive or active range of motion (ROM) of a joint, where in addition to the mobility limiting factor the pain is also present. Repetitive pulsed Magnetic Stimulation (rPMS) appears to be an effective, non-invasive and safety solution for treating this condition. Therefore aim of this study was to evaluate the effect of rPMS in treating joint contracture.

Methods: 30 subjects with joint contracture in the knee were enrolled in this study and divided respectively into Treatment and Control group. The treatment group were delivered with rPMS therapy. The control group was delivered with conventional physiotherapy method (ultrasound). The primary outcome measurements were: 1. Mobility evaluation by goniometry (ROM in degrees while performing flexion) and Patient Functional Assessment Questionnaire (PFAQ) for ability to perform Activities of Daily Living (ADL) and 2. Pain evaluation by 10-point Visual Analog Scale (VAS) for pain perception. Absence of adverse events was set as a secondary measure.

Results: The results of the study show statistical difference (p<0.05) between the levels of improvement of all studied parameters while comparing between both groups. The results suggest greater immobility restoration and pain relieving effect of the rPMS in comparison to conventional physiotherapy method.

Conclusion: rPMS an effective and safe non-invasive method for mobility restoration and pain relief in case of joint contractures. This study suggests the method as beneficial and quality of life ameliorating among patients suffering from immobilized joints accompanied by pain.

Keywords: joint contracture, mobility limitation, pain, repetitive pulse magnetic stimulation, mobility restoration, pain management

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INTRODUCTION

Joint contracture is a limitation in the passive or active range of motion of a joint. Changes in articular structures (bones, cartilage, capsule) or nonarticular structures (muscles, tendons, skin) can prevent a joint from moving [1-3]. Except for the mobility limiting factors, in the common case, pain is also present [4].

Joint contracture can be caused by various reasons such as changes in the joint cartilage, reduced level of synovial fluid or coalescence of the synovium. Other reasons could be shortening or fibrosing muscles - myogenic type of joint contracture, [5] adhesion of connective tissue - dermogenic type, [6,7] after fracture and prolonged use of brace - bone type [3][8]. In addition, neurologic conditions that increase muscle tone or cause weakness could contribute to contracture due to unequal forces generated by opposing muscle group - neurogenic type and any joint could be affected in this manner. [7]

The adopted and proven effective approach for treating joint contracture is the combination of kinesitherapy and physiotherapy [9-11]. However, it has always been essential in healthcare field more effective approaches to be researched. Such method could be the Repetitive Pulse Magnetic Stimulation (rPMS) therapy. Initially addressed to transcranial application, it gains popularity in the very recent decades in peripheral application. Its principle of action is based on magnetic field with induction one Tesla, creating electric currents that interact with neuromuscular tissue. The occurred depolarization of the neuronal cells causes muscle contraction. Therapeutic effects are myostimulative, circulation improvement, swelling release effect, maintaining trophic of the affected area, improving tissue elasticity, pain relief [12,13].

Therefore the aim of this study was to evaluate the effect of rPMS mobility restoration and treating the pain of knee joint in contracture, compared to conventional physiotherapy methods.

MATERIALS AND METHODS

Study design:

Controlled, randomized study conducted in order to evaluate the efficacy of rPMS for treatment of joint contracture, where mobility limiting factors and pain are present. The rPMS was compared with conventional physiotherapy method.

Patients enrollment:

30 patients (n=14 female and n=16 male), aged between 23-62 years with mean age 45.17±9.47, median 46, suffering from knee joint contracture (n=25 traumatic and n=5 osteoarthritis) and experiencing pain in the referred region, were enrolled in this study.

The patients were randomly assigned into two groups: Treatment and Control. The *Treatment group* (n=15 patients) were delivered 6 therapies with rPMS (BTL-6000 Super Inductive System, BTL Industries Ltd.) with total duration 2 weeks (3 treatments per week). The therapy parameters were set as follow: section time: 10 minutes; Frequency modulation: 75 Hz; Amplitude modulation: Type – trapezoid, Rise – 2sec, Hold – 2 sec, Fall – 2 sec, Pause – 6 sec.

The *Control group* (n=15 patients) were delivered equal number of therapies with ultrasound therapy with total duration 2 weeks (3 treatments per week). The therapy parameters were set as followed: Time: 5-8 minutes, Carrier frequency: 1 MHz, Intensity: 0.5W/sm², Contact substance: ultrasound gel.

Outcome measures and statistical evaluation:

Primary outcome measure: i. *Mobility evaluation:* 1. Goniometry - Range of motion (ROM) in the knee was measured while performing flexion. Measurements were marked in degrees. 2. Each patient submitted a 24-part (each activity with grade from 0 to 6) Patient Functional Assessment Questionnaire (PFAQ) for evaluation of the ability to perform Activities of Daily Living (ADL) - Refer to Appendix A. Due to the location of the contracture – in the knee, and its limited influence on all activities in the PFAQ, the parts *Mobility/ Walking* and *Change/ Maintain body position* with the described in Table 1 sub activities were evaluated. ii. *Pain perception* was evaluated by 10-points Visual Analog Scale (VAS) for pain – Refer to Appendix B.. Each patient was asked to rank the level of the pain they experience according to this scale.

Secondary outcome measure: Absence of adverse events related to the therapy.

The data were obtained at pre- (right before the 1st) and post- (right after last) treatment. Average improvements (Mean ± SD) and levels of improvement (%) were calculated. Statistical evaluation of "before" and "after" conditions was performed by the means of Student's t-test (MS Excel Analytics Tool). Values of $p<0.05$ were deemed statistically significant.

RESULTS

All 30 patients completed their participation in the trial. During the course of treatment no adverse events, no abnormalities or side-effects of patients' condition were observed.

Figure 1. illustrates the shares of the diagnoses among all patients, whereas Table 1. contains the averaged outcome data per groups. The disability of all patients to perform the described sub activities from PFAQ corresponded from 'able to do with little difficulty' (0-1) to 'able to do with significant difficulty' (5) as described in the table. The initial level of the pain perception in both groups corresponded to 'moderate' pain according to the used scale.
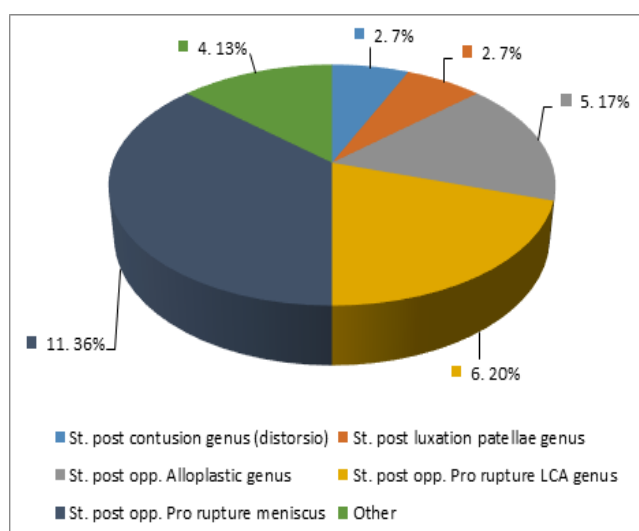

Figure 1: Diagnosis

Parameter		Treatment group (n=15)				Control group (n=15)			
		Pre-	Post-	Δ, %	p	Pre-	Post-	Δ, %	p
		Mean ± SD				Mean ± SD			
ROM, º		95.67±16.99	117.00±11.62	18.77%	<0.05	98.67±12.02	107.67±13.21	8.31%	<0.05
MOBILITY/ WALKING	Walking short distances	2.33±0.72	1.00±0.93	63.33%	<0.05	2.13±0.64	1.13±0.35	41.11%	<0.05
	Walking long distances	3.67±0.62	1.67±0.82	54.44%	<0.05	3.60±0.64	2.20±0.86	35.78%	<0.05
	Walking outdoors	3.40±0.83	1.53±0.83	53.89%	<0.05	3.00±0.93	2.07±0.96	33.33%	<0.05
	Climbing stairs	4.27±0.59	1.73±0.70	57.00%	<0.05	3.93±0.88	2.60±1.12	35.00%	<0.05
	Hopping	4.40±0.99	1.73±0.59	59.33%	<0.05	4.40±0.91	2.60±0.74	39.56%	<0.05
	Running	5.13±0.92	2.47±0.83	50.67%	<0.05	5.40±0.63	3.73±0.70	30.78%	<0.05
CHANGE/ MAINTAIN BODY POSITION	Rolling over	3.47±1.13	0.93±0.70	69.44%	<0.05	3.07±1.22	1.60±0.83	42.78%	<0.05
	Moving - lying to sitting	1.67±0.62	0.40±0.51	73.33%	<0.05	1.73±0.70	0.87±0.35	45.56%	<0.05
	Sitting	1.20±0.56	0.20±0.41	73.33%	<0.05	1.27±0.46	0.80±0.41	33.33%	<0.05
	Bending/ Stooping	0.87±0.64	0.07±0.26	66.67%	<0.05	0.80±0.86	0.60±0.63	37.78%	<0.05
	Kneeling	2.87±1.19	0.87±0.74	62.33%	<0.05	2.60±1.06	1.40±0.51	40.00%	<0.05
	Standing	0.67±0.72	0.00±0.00	53.33%	<0.05	0.87±0.74	0.47±0.52	30.00%	<0.05
VAS		4.00±0.93	0.73±0.46	82.67%	<0.05	4.07±0.59	1.87±0.83	53.56%	<0.05

Table 1: Outcome data

Levels of improvement are calculated in Table 2 and illustrated in Figure 2.

Parameter		Pre-treatment (T0)			Post-treatment(T1)		
		Treatment	Control	p	Treatment	Control	p
		mean ± SD			ΔT1-T0%		
ROM, º		95.67±16.99	98.67±12.02	NS	18.77%	8.31%	<0.05
MOBILITY/ WALKING	Walking short distances	2.33±0.72	2.13±0.64	NS	63%	41%	<0.05
	Walking long distances	3.67±0.62	3.60±0.64	NS	54%	36%	<0.05
	Walking outdoors	3.40±0.83	3.00±0.93	NS	54%	33%	<0.05
	Climbing stairs	4.27±0.59	3.93±0.88	NS	57%	35%	<0.05
	Hopping	4.40±0.99	4.40±0.91	NS	59%	40%	<0.05
	Running	5.13±0.92	5.40±0.63	NS	51%	31%	<0.05
CHANGE/ MAINTAIN BODY POSITION	Rolling over	3.47±1.13	3.07±1.22	NS	69%	43%	<0.05
	Moving - lying to sitting	1.67±0.62	1.73±0.70	NS	73%	46%	<0.05
	Sitting	1.20±0.56	1.27±0.46	NS	73%	33%	<0.05
	Bending/ Stooping	0.87±0.64	0.80±0.86	NS	67%	38%	<0.05
	Kneeling	2.87±1.19	2.60±1.06	NS	62%	40%	<0.05
	Standing	0.67±0.72	0.87±0.74	NS	53%	30%	<0.05
VAS		4.00±0.93	4.07±0.59	NS	82.67%	53.56%	<0.05

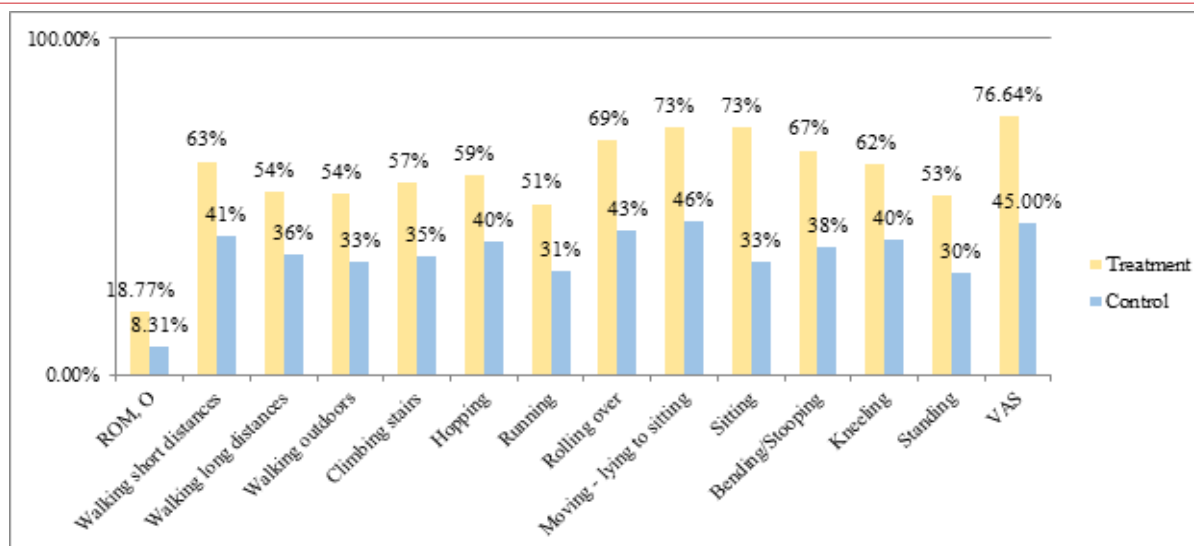**Table 2:** Improvements and Levels of improvement

Figure 2: Levels of improvement

The level of improvement in passive ROM in the treatment group was 18.77% whereas this parameter in the control group was 8.31% (p<0.05).

Major improvement in 'Mobility/ Walking' part was observed in '*Walking short distances*' with 63% to level '*able to do with little difficulty*' and 41 % to level '*able to do with little- moderate difficulty*' respectively for treatment and control group (p<0.05). Least improvements were observed in '*Running*' with 51% to '*able to do with little- moderate difficulty*' and 31% to '*able to do with moderate difficulty*', respectively for treatment and control group (p<0.05).

Major improvement in '*Change/ Maintain body position*' part was observed in '*Sitting*' and '*Moving lying-sitting position*' with 73% to level '*able to do with no difficulty*' for treatment group and 46 % improvement in '*Moving lying-sitting position*' to level '*able to do with little difficulty*' respectively for control group (p<0.05). Least improvements were observed in '*Standing*' with 46% and 30% to '*able to do with no difficulty*' respectively for treatment and control group (p<0.05). However the pre-treatment outcome values were between '*able to do with little difficulty*' to '*able to do with no difficulty*', or the described activity has not been very limited in pre-treatment condition – the specific location of the joint contracture does not have a major influence on the sitting ability of an individual.

Statistical difference between the pre-treatment conditions in both groups was not present. Statistical difference between the pre-treatment and post-treatment condition were observed in both groups (p<0.05). The levels of improvement in the Treatment groups were greater than the improvements observed in the control group (p<0.05).

The pain decrease observed was 82.67% in the treatment group to level '*no pain*' – '*mild pain*' and 53.56 % in the control group to level '*mild*', from '*nagging, uncomfortable, troublesome pain*' in both groups.

DISCUSSION

Mobility restoration effect of the rPMS has been studied by Struppler et al. 2007 among 8 patients who have shown improvement assumed to be led by increase of neural activation in the contralateral premotor cortex and the posterior parietal cortex [12]. *Massé-Alarieet al. 2013* researched the therapeutic effect of the rPMS among 13 patients with chronic low back pain and limited mobility. The active group demonstrated improvement in the disability, whereas the disability was not influenced in the control group. The mechanism of action remains uncertain [14]. The ROM and PFAQ for ADL data from the current study confirm mobility restoration effect of both studied methods, yet greater effect of the studied rPMS method. This effect is assumed to be led by improved tissue elasticity and increased local circulation.

Pain relief effect of the rPMS directly applied on the painful limb has been studied by *Pujo et al. 1998* among 30 patients randomized into active and placebo-controlled groups. The pain decrease effect was 59% in the active group (whereas a 14% pain decrease was present in the control). The mechanism of action remains uncertain [13]. *Lo et al. 2011* has researched the pain relief effect of the rPMS among 20 patients. 62.3% pain decrease was observed in the active group (whereas the pain decrease in the control was 6.1%). The pain relief effects are assumed to be a result of disrupting afferent nerve fibers or activation of spinal supra spinal inhibitory neurons [15]. The current study demonstrates greater pain relief effect - 82.67% (whereas the control group showed 53.56%). This effect is suggested by the circulation improvement.

CONCLUSION

The results of this study evaluated the rPMS method as an effective, safe and non-invasive method mobility restoration in case of joint contractures and particularly knee joint, where pain relief effect is also present. The therapy was very-well tolerated by the patients and no side effects, nor abnormalities, nor was aggravation of patient's condition observed. The clinical effects are assumed to be led by depolarization of the neuronal cells, however further researches should take place.

In conclusion, this study suggests the method as beneficial and quality of life ameliorating among patients suffering from joint contractures accompanied by pain.

REFERENCES

[1] Ian A. Trail, Andrew Fleming. Disorders of the Hand. Volume 3;2014.

[2] Kevin C. Chung. Preventing and Avoiding Complications in Hand Surgery.Hand Clinics.2015

[3] Walter R. Frontera, Julie K. Silver, Thomas D. Rizzo Jr. Essentials of Physical Medicine and Rehabilitation.3rd edition;2014.

[4] Anna Winterbottom, Facil Tesfaye, Histories of Medicine and Healng in the Indian Ocean World, Volume One: The Medieval and Early Modern Period, Springer 2016, 204.

[5] Lawrence Russell Robinson, Trauma Rehabilitation, Lippicott Williams & Wilkins, 2008, 332-146

[6] Joseph M. McCulloch, Luther C. Kloth, Wound Healing: Evidence-Based Managmend, F.A. Davis. 2010, 608-376.

[7] Mary Lynn A. Jocobs, Noelle Austin, Noelle M. Austin, Splinting the Hand and Upper Extremity: Principles and Process, Lippincott Williams & Wilkins 2003, 498-429, 498-446

[8] Warren I. Hammer, Functional Soft-tissue Examination and Treatment by Manual Methods, Jones & Barlett Learning, 2007, 775-26.

[9] Lisiński P, Grabarczyk G. [Aspects of physiotherapy in treatment of shoulderjoint pain]. Chir Narzadow Ruchu Ortop Pol. 2005;70(4):295-9.

[10] Jandrić S. Effects of physical therapy in the treatment of the posttraumatic elbow contractures in the children. Bosn J Basic Med Sci. 2007 Feb; 7(1):29-32.

[11] Matijević R, Stanković M, Ninković S, Savić D, Milankov M. [Treatment of knee flexion contracture in patients with chronic juvenile arthritis--a case report]. Med Pregl. 2006 May-Jun;59(5-6):273-6.

[12] Albrecht Struppler, Ferdinand Binkofski, Bernhard Angerer, Michael Bernhardt, Sabine Spiegel, Alexander Drzezga, Peter Bartenstein, A fronto-parietal network is mediating improvement of motor function related to repetitive peripheral magnetic stimulation: A PET-H2O15 study. Neuroimage. 2007;36 Suppl 2:T174-86.

[13] Pujol J, Pascual-Leone A, Dolz C, Delgado E, Dolz JL, AldomaJ. The effect of repetitive magnetic stimulation on localized musculoskeletal pain. Neuroreport. 1998;9(8):1745—8.

[14] Massé-Alarie H, Flamand VH, Moffet H, Schneider C. Peripheral neurostimulation and specific motor training of deep abdominal muscles improve posturomotor control in chronic low back pain. Clin J Pain. 2013 Sep;29(9):814-23.

[15] Lo YL, Fook-Chong S, Huerto AP, George JM. A randomized, placebo-controlled trial of repetitive spinal magnetic stimulation in lumbosacral spondylotic pain. Pain Med. 2011 Jul;12(7):1041-5.

PATIENT FUNCTIONAL ASSESSMENT QUESTIONNAIRE

PATIENT NAME: _____   DATE: _____

INSTRUCTIONS: Circle the level of difficulty for each activity.		0 = Absolute no difficulty	1 = Able to do w little difficulty	2 = Able to do w lit-mod difficulty	3 = Able to do w mod difficulty	4 = Able to do w mod-signif difficulty	5 = Able to do w signif difficulty	6 = Unable to do at all	Not applicable
MOBILITY/WALKING	1 Walking short distances	0	1	2	3	4	5	6	n/a
	2 Walking long distances	0	1	2	3	4	5	6	n/a
	3 Walking outdoors	0	1	2	3	4	5	6	n/a
	4 Climbing stairs	0	1	2	3	4	5	6	n/a
	5 Hopping	0	1	2	3	4	5	6	n/a
	6 Running	0	1	2	3	4	5	6	n/a
CHANGE/MAINTAIN BODY POSITION	1 Rolling over	0	1	2	3	4	5	6	n/a
	2 Moving - lying to sitting	0	1	2	3	4	5	6	n/a
	3 Sitting	0	1	2	3	4	5	6	n/a
	4 Bending/Stooping	0	1	2	3	4	5	6	n/a
	5 Kneeling	0	1	2	3	4	5	6	n/a
	6 Standing	0	1	2	3	4	5	6	n/a
CARRY/MOVE/HANDLE OBJECTS	1 Pushing	0	1	2	3	4	5	6	n/a
	2 Pulling	0	1	2	3	4	5	6	n/a
	3 Reaching	0	1	2	3	4	5	6	n/a
	4 Grasping	0	1	2	3	4	5	6	n/a
	5 Lifting	0	1	2	3	4	5	6	n/a
	6 Carrying	0	1	2	3	4	5	6	n/a
SELF CARE	1 Dressing/Clasp b/h back	0	1	2	3	4	5	6	n/a
	2 Doing light housework	0	1	2	3	4	5	6	n/a
	3 Prep meals/kitchen tasks	0	1	2	3	4	5	6	n/a
	4 Bathroom activities	0	1	2	3	4	5	6	n/a
	5 Sleeping Ability	0	1	2	3	4	5	6	n/a
	6 Hygiene (comb hair/brush teeth)	0	1	2	3	4	5	6	n/a

_____   _____
PATIENT SIGNATURE   DATE

_____   _____
REVIEWED BY THERAPIST / CREDENTIALS   DATE

Appendix B:

0	1	2	3	4	5	6	7	8	9	10
No pain		Mild, annoying pain		Nagging, uncomfortable, troublesome pain		Distressing, miserable pain		Intense, dreadful, horrible pain		Worst possible, unbearable, excrutiating pain