นิพนธ์ต้นฉบับ Original Article

ผลลัพธ์แบบทันทีภายหลังการกระตุ้นระบบประสาทส่วนปลาย ด้วยคลื่นแม่เหล็กไฟฟ้าครั้งเดียว ในผู้ป่วยกลุ่มอาการเส้นประสาทมีเดียน ถูกกดทับในอุโมงค์ข้อมือ

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บทคัดย่อ

การวิจัยเพื่อดูประสิทธิภาพของเครื่องกระตุ้นระบบประสาทส่วนปลายด้วยคลื่นแม่เหล็กไฟฟ้า (Repetitive Peripheral Magnetic Stimulation; rPMS) ครั้งเดียวในผู้ป่วยอาการเส้นประสาทมีเดียนถูกกดทับในอุโมงค์ข้อมือ (Carpal Tunnel Syndrome; CTS) กลุ่มตัวอย่าง คือ ผู้ป่วย CTS 34 ราย ที่ได้รับการรักษามากกว่า 6 สัปดาห์ (ยาและสอนท่าบริหาร) ถูกสุ่มเป็นสองกลุ่ม กลุ่มทดลอง 17 คน ได้รับ rPMS ครั้งเดียว และกลุ่มหลอก 17 คน ได้รับ rPMS แบบหลอก ทั้งสองกลุ่มยังได้รับการรักษามาตรฐานร่วม การประเมินประกอบด้วยคะแนนปวด(VAS), แรงบีบมือ (grip strength) และคะแนนแบบสอบถามบอสตันฉบับภาษาไทย (Thai BCTQ) เวลาประเมินคือ ก่อนรักษา, ทันทีหลังรักษา 15 นาที (VAS, grip strength) และ 1 สัปดาห์หลังรักษา (VAS, Thai BCTQ) เครื่องมือที่ใช้ในการวิจัยคือ เครื่องกระตุ้นระบบประสาทส่วนปลายด้วยคลื่นแม่เหล็กไฟฟ้า โดยใช้โปรโตคอลที่ผู้วิจัยออกแบบ วิเคราะห์ข้อมูลโดย 1) เปรียบเทียบคะแนนปวดชา (VAS) โดยใช้สถิติ Independent t–test 2) เปรียบเทียบแรงบีบมือ โดยใช้สถิติ Independent t–test 3) เปรียบเทียบคะแนนแบบสอบถามบอสตันฉบับภาษาไทย โดยใช้สถิติ Independent t–test

ผลการวิจัย พบว่า rPMS ครั้งเดียวในผู้ป่วย CTS ยังไม่แสดงผลที่เหนือกว่ากลุ่มหลอกในการลดอาการปวด ชามือ (หลังการรักษา 15 นาที –0.59 (–1.87,0.70) P = 0.370, หลังการรักษา 1 สัปดาห์ –1.00 (–2.44, 0.44) หรือเพิ่มความแข็งแรงของมือ (–0.12 (2.04,1.81) P = 0.902) และคะแนนThai BCTQ (–0.09 (–0.47,0.30) P = 0.652)

คำสำคัญ: การกระตุ้นระบบปราสาทส่วนปลายด้วยคลื่นแม่เหล็กไฟฟ้า กลุ่มอาการประสาทมีเดียนถูกกดทับในอุโมงค์ข้อมือ ผลการลดปวดแบบทันที

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The immediate effect after a single session of using Repetitive Peripheral Magnetic Stimulation (rPMS) in patients with Carpal Tunnel Syndrome

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Abstract

The study aimed to investigate the efficacy of a single session of repetitive peripheral magnetic stimulation (rPMS) in patients with carpal tunnel syndrome (CTS) caused by median nerve compression. The sample consisted of 34 CTS patients who had been receiving treatment for more than six weeks (medication and exercise). They were randomly divided into two groups: 17 participants in the experimental group received a single session of rPMS, while 17 participants in the control group received sham rPMS. Both groups continued receiving standard treatment. Evaluations included pain scores (VAS), grip strength, and the Thai version of the Boston Carpal Tunnel Questionnaire (Thai BCTQ). Assessments were conducted at baseline, 15 minutes after treatment (VAS, grip strength), and one week post–treatment (VAS, Thai BCTQ).The research instrument used was a repetitive peripheral magnetic stimulation machine, following a protocol designed by the researchers. Data analysis was performed using the following statistical methods: 1) comparison of pain and numbness scores (VAS) with the Independent t–test, 2) comparison of grip strength with the Independent t–test, and 3) comparison of Thai BCTQ scores with the Independent t–test.

The results showed that a single session of rPMS in CTS patients did not demonstrate superior effects compared to the sham group in reducing pain and numbness (15 minutes post–treatment: –0.59 (–1.87, 0.70), P = 0.370; one week post–treatment: –1.00 (–2.44, 0.44) or in improving hand strength (–0.12 (2.04, 1.81), P = 0.902) and Thai BCTQ scores (–0.09 (–0.47, 0.30), P = 0.652).

Keywords: Peripheral nerve stimulation with electromagnetic waves, electromagnetic stimulation, carpal tunnel syndrome, immediate pain reduction effects.

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Introduction

Carpal Tunnel Syndrome (CTS) is the most common condition among nerve compression syndromes. Prevalence of CTS was 16% (95% CI: 0.068–0.346) in North America (eight studies), 12.1% (95% CI: 0.065–0.216) in Asia (eleven studies), 45% (95% CI: 0.124–0.828) in Europe (six studies), 7.9% (95% CI: 0.039–0.156) in Africa (three studies), and 7.1%(95% CI: 0.008–0.438) in South America (two studies)[1]. At Maharat Nakhon Ratchasima Hospital, there are a significant number of patients with carpal tunnel syndrome, approximately 500 cases per year, who visit the outpatient clinic for examinations. The condition is caused by compression of the median nerve in the carpal tunnel. Patients typically present numbness in the thumb, index finger, and middle finger, along with wrist pain, which often worsens at night. This may lead to reduced grip strength, significantly affecting daily activities and the patient's quality of life[2]. The treatment for CTS is divided into surgical and non–surgical approaches. Surgery offers a safe and effective outcome in terms of symptom relief compared to non–surgical methods. However, it carries more side effects and a risk of persistent symptoms post–surgery, reported in up to 20% of cases[3,4]. Non–surgical treatments, such as steroid injections, wrist splints[5], and other techniques, have been found effective and are alternative options for managing the condition.

Repetitive Peripheral Magnetic Stimulation (rPMS) is a new and simple method for nerve stimulation that helps reduce pain and numbness while promoting hand function recovery. Current studies have reported that rPMS mechanisms include increasing blood circulation, enhancing the function of the sodium–potassium pump, and reducing inflammation[6,7,8].

Research involving rPMS in animal models, such as rats with sciatic nerve injury, demonstrated improved nerve growth and functional recovery[9,10,11,12]. Studies have also shown that applying rPMS to spinal nerve roots, peripheral nerves, or muscles can reduce pain and restore muscle strength[13]. Furthermore, rPMS have been used effectively to alleviate muscle pain[14].

For CTS, various rPMS protocols have been studied, but there is currently no standardized treatment protocol. For example, a pilot study by Savulescu Simona Elena et al in 2021 investigated the use of rPMS in 5 CTS patients[2]. They utilized a MagVenture MagPro X100 stimulator with an RT–120 racetrack coil, providing stimulation once daily for 10 days. Each session consisted of 5 pulses per train for 100 trains, with a frequency of 10 Hz, lasting 0.5 seconds, and a 5–second rest interval, totaling 500 pulses. The study found a 33% improvement in the Boston Carpal Tunnel Questionnaire scores in all patients and an average grip strength increase of 6 kilograms.

Another study by Dakowicz A et al.[15] was conducted as a randomized controlled trial (RCT) involving 38 CTS patients, divided into a low–level laser therapy group (18 patients) and an electromagnetic stimulation group (20 patients). In the electromagnetic stimulation group, sessions lasted 15 minutes using a Magnetronic MF–10 device (Elektronika i Elektromedycyna, Otwock, Poland) with a sinusoidal field at a frequency of 10–40 Hz and an induction of 1.0–5.0 mT. Pain reduction was observed in the group treated with laser by 44% and in the group treated with electromagnetic waves by 38%, with statistical significance ($p<0.05$). And the research of Pujol J et al[16] has each session included 100 pulses per

train, with 80 trains at a frequency of 20 Hz, lasting 5 seconds, followed by a 25–second rest, for a total of 8,000 pulses. It was found to help reduce pain by 59% in the rPMS group and 14% in the placebo group, with significant statistical improvement (p=0.001). From the review of the research, no adverse effects were found, and it is considered to have good safety.

Currently, studies utilizing rPMS for CTS remain limited, with some protocols being challenging to implement in clinical practice. These include long treatment durations, such as 40–minute sessions[16], and the requirement for continuous follow–up, with patients need to complete 10 sessions or more[14,15].

However, there is one study by Pujol et al that uses a single 40–minute rPMS in musculoskeletal disorders and CTS. This study demonstrated that a single 40–minute rPMS session could reduce pain. The authors adapted this protocol to a 20–minute stimulation session and found it effectively reduced pain and numbness in CTS patients. This has sparked interest in studying the immediate effects of rPMS to alleviate pain and numbness in CTS patients.

Objectives

To investigate the immediate pain–reducing effects of rPMS in CTS patients, as measured by the Visual Analog Scale (VAS) for hand pain and numbness, grip strength assessment and Thai BCTQ.

Methods

Study design

This study was a double–blind randomized controlled study conducted at the Department of Rehabilitation Medicine, Maharat Nakhon Ratchasima Hospital, a tertiary care hospital in Nakhon Ratchasima, Thailand. Hand grip strength was measured by standing straight with feet 25–30 cm apart, holding the device comfortably with the second knuckle bearing the weight, keeping the elbow straight, and the arm slightly away from the body. Participants squeezed the device with maximum force without touching their body or swinging the device, and the best result from two trials (measured in kilograms) was recorded before treatment[17]

Ethical consideration

Ethical approval was obtained from the Maharat Nakhon Ratchasima Hospital Institutional Review Board (NO 93 /2023) and was registered in the Thai Clinical Trial Registry (TCTR 20230921006). Both groups of patients received the same standard treatment and were under the care of physicians throughout the procedure. In case of any issues or complications, the researchers could be contacted at any time.

Participants

From August 2023 to March 2024, CTS patients who have failed conservative treatment for at least 6 weeks (medication, tendon gliding exercise, wrist splint and steroid injection)came to the Outpatient Department of Rehabilitation Medicine, Maharat Nakhon Ratchasima Hospital and who met the inclusion criteria were recruited into the study. The inclusion criteria included age 18 to 75 years, have pain and numbness in the hand, the physical examination from the physician leading to the diagnosis of CTS and receiving the electrodiagnostic study confirming mild and moderate severity of CTS. This electrophysiological grading in this study uses the AAEM classification for determining the degree of CTS[18] which mild CTS described by only sensory delayed peak latency and falling sensory amplitude and moderate CTS described by abnormal median sensory interaction

with addition of motor distal latency prolongation. The exclusion criteria included unstable vital signs, having contraindications for rPMS including a history of cardiac pacemaker, cochlear implant, metallic implant or open wound in wrist and hand, pregnancy, epilepsy and patients who cannot communicate in Thai language. Polyneuropathy, other mononeuropathy, brachial plexopathy or central nervous system pathology such as stroke and spinal cord lesion were excluded.

The sample size calculation was based on the study by Pujol J et al[16]. The power of the study was set at 80%, and the significance level was 0.05. There were 11 patients required in each group. Adding 50% drop out, the number of patients was increased to 17 patients in each group, and 34 patients in total were recruited.

Randomization

The patients were randomized to either an intervention or a sham group by a simple randomization with 1:1 ratio. After baseline data were evaluated, the co–authors received the patients' group allocation in a sealed envelope. The patients and outcome assessors were blinded to the intervention assignment.

Intervention

Patients in the intervention and sham groups received rPMS for 20 minutes per session. Patients in the intervention group received real rPMS with parabola coil. The electromagnetic stimulation device used was the Magnetic Field Therapy device, Magventure MagproR20. The treatment protocol was 20 Hz frequency, 100 pulses per train, for 40 trains with the intertrain interval of 25 seconds. The total time of treatment was 20 minutes and the total pulses was 4,000 pulses. The intensity started at 20% then increased by 2% steps until the patients perceived significant local sensation without excessive discomfort[16]. The sham group received sham rPMS, with the non–magnetic side of the coil positioned on the wrist parallel to the forearm. The electromagnetic stimulation device used was the Magnetic Field Therapy device, Magventure MagproR20, equipped with a figure–of–eight coil. The stimulation protocol included a frequency of 20 Hz, 100 pulses per train (on–time 5 seconds per train), 40 trains per session, with an inter–train interval of 25 seconds, totaling 4,000 pulses in 20 minutes. The intensity was set to 30% to produce auditory feedback similar to that of the experimental group. Both groups received standard treatment, which included the following: Paracetamol (500 mg), taken as needed, one tablet orally every 8 hours; Gabapentin (300 mg), one tablet orally at bedtime; and B 1–6–12, one tablet orally three times daily after meals. Participants were instructed to refrain from seeking any additional treatments outside of those provided by the hospital during the 1–week study period.

Outcome measurements

The clinical outcome measure was visual analog scale after 15 minutes and 1 week, grip strength after 15 minutes and Thai BCTQ after 1 week. The visual analog scale (VAS) for hand pain and numbness (0–10 scale, where 0 is no pain and 10 is the worst pain). Thai BCTQ was also administered[19]. Thai BCTQ was a reliable tool (Cronbach's alpha = 0.86 for the symptom severity scale) for assessing CTS symptoms. Before the rPMS treatment the patients were evaluated using VAS, grip strength, and the Thai BCTQ. Post–treatment evaluations included VAS and grip strength 15 minutes after the treatment and VAS and Thai BCTQ one week after the treatment.

Statistical methods

The baseline characteristics of the intervention

and the control groups were analyzed with descriptive statistics including frequency, percentage, mean, and standard deviation. Comparative analysis by independent T–tests were used to compare outcomes between the intervention group and the sham group. A statistically significant difference was determined at a P–value < 0.05.

Results

The study included a total of 34 patients, all of whom were successfully followed up (no drop out).

Based on the demographic data collected, as shown in Table 1, In the intervention group, the median age of participants is 49.88 years (IQR: 43–58), while in the sham group, the median age is 52.64 years (IQR: 47–57). In terms of gender distribution, there are 4 males (23.53%) and 13 females (76.47%) in the intervention group, compared to 2 males (11.76%) and 15 females (88.24%) in the sham group. The mean body mass index (BMI) for the intervention group is 27.07 kg/m^2 (SD: 20.81–36.33) and for the sham group, it is 24.04 kg/m^2 (SD: 19.94–27.34). Regarding underlying diseases, 1 participant (5.88%) in the intervention group has diabetes mellitus, while 5 participants (29.41%) in the sham group have diabetes mellitus. Additionally, 1 participant (5.88%) in the intervention group has rheumatoid disease, and none in the sham group. For gout, there is 1 participant (5.88%) in both groups. When considering the affected wrist, in the intervention group, 8 participants (47.06%) have left wrist involvement, while 8 participants (47.06%) have right wrist involvement and 1 participant (5.88%) has bilateral wrist involvement. In the sham group, 9 participants (52.94%) have left wrist involvement, 6 participants (35.29%) have right wrist involvement, and 2 participants (11.76%) have bilateral wrist involvement. The median duration of symptoms is 4 months (IQR: 3–6) in the intervention group and 3 months (IQR: 6–8) in the sham group.

According to the severity of carpal tunnel syndrome (CTS) assessed by electrodiagnostic testing, 8 participants (47.06%) in the intervention group have mild CTS, while 9 participants (52.94%) have moderate CTS. In the sham group, 5 participants (29.41%) have mild CTS and 12 participants (70.59%) have moderate CTS. Regarding previous treatments, 5 participants (29.41%) in the intervention group have used wrist splints, while 3 participants (17.64%) in the sham group have used wrist splints. For steroid injections, 2 participants (11.76%) in the intervention group and 1 participant (5.88%) in the sham group have received this treatment. Patients in both groups did not have different baseline characteristics.

Table 1. clinical characteristics of the patients between intervention group (N=17) and sham group (N=17)

Characteristics	Intervention group	Sham group	P value
Age (years)			
Median (IQR)	49.88(43,58)	52.64(47,57)	0.5477*
Gender, n (%)			
Male	4(23.53)	2(11.76)	1.00*
Female	13(76.47)	15(88.24)	1.00*
BMI (kgs/m^2)			
Mean (SD)	27.07(20.81,36.33)	24.04(19.94, 27.34)	0.1446*
Underlying diseased, n (%)			
Diabetes mellitus	1(5.88)	5(29.41)	
Rheumatoid disease	1(5.88)	0(0.00)	
Gout	1(5.88)	1(5.88)	
Affected wrist, n (%)			
Left wrist	8(47.06)	9(52.94)	
Right wrist	8(47.06)	6(35.29)	
Bilateral wrist	1(5.88)	2(11.76)	
Duration of symptoms(months)			
Median (IQR)	4(3,6)	3(6,8)	0.691*
Severity of CTS by electrodiagnostic, n (%)			
Mild	8(47.06)	5(29.41)	
Moderate	9(52.94)	12(70.59)	
Previous treatment, n (%)			
Wrist splint	5(29.41)	3(17.64)	
Steroid injection	2(11.76)	1(5.88)	

* The level of statistical significance was set at 0.05.

Comparison of VAS, Grip Strength, and Thai BCTQ Scores (As shown in table 2) The mean VAS score before treatment in intervention and sham groups were 5.1 (1.76) and 6.0 (1.50), respectively. Immediately after treatment, the scores were 3.9 (2.23) for intervention group and 4.5 (1.97) for sham group. One week after treatment, the scores were 3.9 (2.34) for intervention group and 4.9 (2.03) for sham group.

The mean grip strength before treatment in intervention group and sham group was 24.94 (7.47) and 20.76 (9.62), respectively. Immediately after treatment, the scores were 26.06 (7.13) for intervention group and 22.00 (9.43) for sham group.

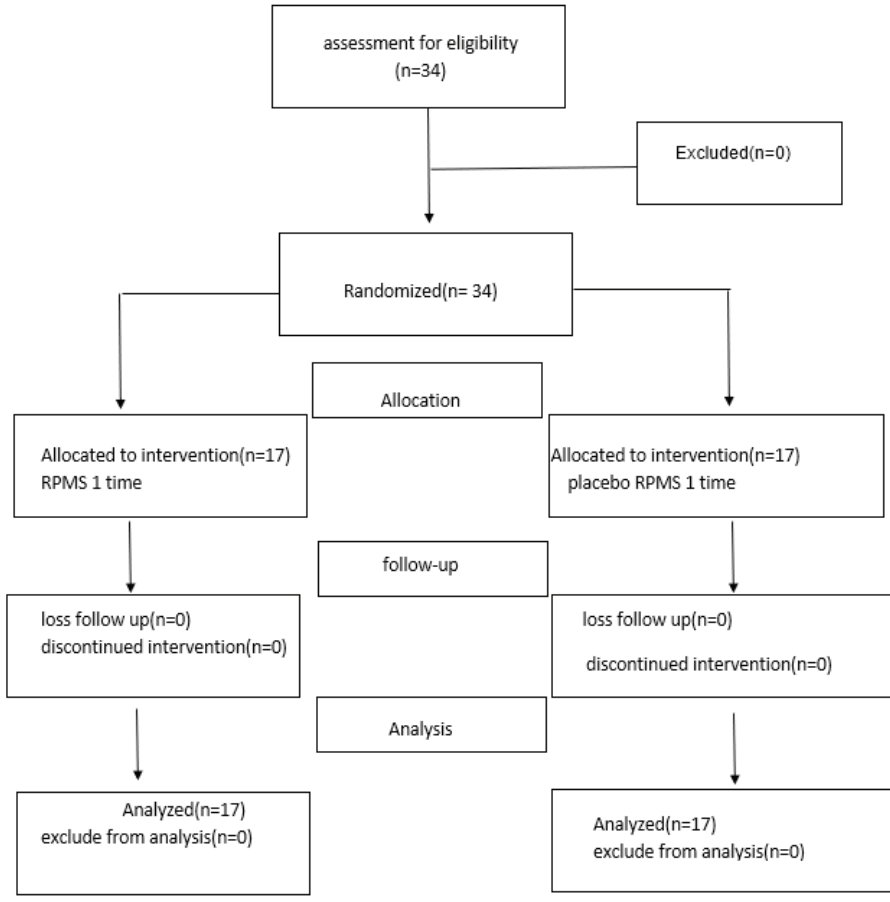
The mean Thai BCTQ score before treatment in intervention group and sham group was 2.31 (0.80) and 2.48 (0.62), respectively. One week after treatment, the scores were 1.97 (0.78) for intervention group and 2.22 (0.73) for sham group.

Table 2. effectiveness of rPMS on primary and secondary outcomes between intervention group (N=17) and sham group (N=17)

Group	**Intervention**	**Sham**	**Mean difference between two groups**
Primary outcome (n=34) VAS			
at baseline	5.1 (1.76)	6.0 (1.50)	–0.88(–2.11,0.35) P = 0.160*
after 15 minutes	3.9 (2.23)	4.5 (1.97)	
change from baseline	–1.24 (–2.17, –0.30) P = 0.010*	–1.53(–2.47, –0.59) P = 0.001*	–0.59(–1.87,0.70) P = 0.370*
after 1 week	3.9 (2.34)	4.9 (2.03)	
change from baseline	–1.24(–2.28, –0.19) P = 0.020*	–1.12(–2.16, –0.08) P = 0.036*	–1.00(–2.44, 0.44) P = 0.173*
Secondary outcome(n=34)			
Grip strength			
at baseline	24.94 (7.47)	20.76 (9.62)	
after 15 minutes	26.06 (7.13)	22.00 (9.43)	
change from baseline	1.12 (2.57)	1.24 (2.93)	–0.12 (2.04,1.81) P = 0.902*
Thai BCTQ			
baseline	2.31 (0.80)	2.48 (0.62)	
after 1 week	1.97 (0.78)	2.22 (0.73)	
change from baseline	–0.34 (0.50)	–0.26 (0.57)	–0.09 (–0.47,0.30) P = 0.652*

* The level of statistical significance was set at 0.05.

Fig 1 Flow chart



Statistical Finding

After a single session of rPMS, the VAS scores significantly decreased in both groups, both immediately after the treatment and one week later. In the intervention group, the immediate VAS reduction was –1.24 (–2.17, –0.30), with a p–value of 0.010, and the one–week VAS reduction was –1.24 (–2.28, –0.19), with a p–value of 0.020. Similarly, in the sham group, the immediate VAS reduction was –1.53 (–2.47, –0.59), with a p–value of 0.001, and the one–week VAS reduction was –1.12 (–2.16, –0.08), with a p–value of 0.036.

However, there were no statistically significant differences between the two groups in terms of immediate and one–week post–treatment effects. The immediate difference in VAS scores was –0.59 (–1.87, –0.70), with a p–value of 0.370, while the one–week difference was –1.00 (–2.44, –0.44), with a p–value of 0.173. Similarly, no significant differences were observed between the groups in grip strength or Thai BCTQ scores. For grip strength, the difference was –0.12 (–2.04, 1.81), with a p–value of 0.902, and for Thai BCTQ scores, the difference was –0.09 (–0.47, –0.30), with a p–value of 0.652.

Safety

No side effects were reported in any of the patients All patients tolerated rPMS well. None of the patients reported excessive discomfort during stimulation of experienced worse pain immediately after the sessions. No patient showed a rebound effect in the entire follow–up period, similarly to the research of Pujol et.al[16]

Discussion

This study evaluated the immediate pain–relief effects of a single session of peripheral electromagnetic stimulation for patients with carpal tunnel syndrome. The mechanism of rPMS is thought to reduce pain and numbness in CTS patients by functioning similarly to TENS devices[16]. This includes reducing nerve signal transmission in A–delta and C fibers via the gate control theory, thereby alleviating pain[20].

Significant visual analog scores reductions were observed in both groups when comparing pre–treatment to post–treatment within the same group. However, there were no statistically significant differences between groups. No statistically significant differences of grip strength and Thai BCTQ Scores were observed within or between groups. Other factors that may impact the research include the use of pain medication. Both groups received the same pain relief medication, but the intake of medication was not recorded. The amount of medication taken may vary between groups, just like the activities or tasks that involve wrist use.

These results align with prior studies by Baute V et al[21] that showed no statistically significant improvements in the Boston Carpal Tunnel Questionnaire, Dakowicz A et al[15] that showed no statistically significant pain reduction between the groups. However, Pujol J et al[16] Weintraub M et al[20] Michael I. Weintraub et al[22]demonstrated positive results with rPMS for pain reduction. The different results are caused by numerous factors, including coil design and location, duty cycle, duration/total number of stimuli, frequency and intensity that may influence the effectiveness of rPMS for pain reduction.

This study utilized dosage of 4,000 pulses of rPMS over carpal tunnel region combined with standard treatment, The treatment protocol was 20 Hz frequency, 100 pulses per train, for 40 trains with the intertrain interval of 25 seconds. The total time of treatment was 20 minutes and the total pulses was 4,000 pulses. The intensity started at 20% then increased by 2% steps until the patients perceived significant local sensation without excessive discomfort. The dosage was adapted from the study by Pujol J et al., who used 8,000 pulses of rPMS in musculoskeletal disorder and CTS, 40 minutes per session, 1 session. Their findings showed that dose can reduce pain. However, our study found no significant difference in pain reduction between groups. There were a wide range of dose rPMS which showed effectiveness in pain reduction, including 1–5mT, 10 session[15], 500 pulses, 9 min, 10 session[14], 1,000 pulses, 20 min, 1 session[23]. It is quite challenging to compare the dosage levels of electromagnetic waves due to various factors, such as the use of different types of magnetic generators, varying poles, stimulators from different brands, and different coil types. Some studies utilized a figure–of–eight coil initially and switched to a circular coil once the temperature reached 40°C[16] Other studies did not specify the average intensity used[23]. Additionally, the different depth of the stimulated tissue makes it difficult to estimate the number of electromagnetic waves affecting the targeted area accurately. Coil design and location, evidence suggest that round/parabola coil is more efficient for stimulating the deep conductive structures, conversely figure of 8 is appropriate for selective recruitment of superficial structures, such as muscles and nerves, without co–activation or surrounding tissues. However, the figure of eight coils can't be used in this protocol due to overheating. This may be one of the reasons

why this research did not perform better than the placebo group. Future studies will have to compare the effectiveness and selectivity of different coil designs at different sites of stimulation[24]. Intensity, most research using subthreshold intensities focused on pain reduction. intensity seems to be a determining factor for rPMS after–effect. The choice depends on the depth of the targeted structure and on the afferent recruit[24].

The term slow or low–frequency stimulation refers to stimulus rates of 1 Hz or less, which have inhibitory effects, whereas high–frequency stimulation refers to stimulus rates of 5 Hz or more, which have excitatory effect in the brain. The influence of frequency and the total number of rPMS stimuli remain inconclusive[25]. Further studies are needed to determine the intensity required to effectively reduce pain in CTS.

The Visual Analog Scale (VAS) was selected to be the assessment tool in this study due to being widely used for measuring pain with high validity and reliability[26] (ICC = 0.97, 95% CI = 0.96–0.98)[27]. However, there were limitations including assuming pain is a linear phenomenon and uniform scaling by all patients, as pain is subjective. The sham group did not receive any magnetic waves but experienced a significant reduction in pain. The researchers hypothesized that this was due to the placebo effect. This effect is significant in studies involving subjective measures like pain perception, where patient expectations and beliefs can alter reported outcomes. Jamar Dynamometer was highly reliable (ICC [3,1] = 0.98) and valid (ICC [2,K] = 0.99)[28] for measuring grip strength. Decreased grip strength in CTS is likely due to weakening of the intrinsic thenar muscles and sensory changes affecting precision grip motions[29]. Thai BCTQ was a reliable tool (Cronbach's alpha = 0.86 for the symptom severity scale)[19] for assessing CTS symptoms. However, since no significant pain reduction was observed between groups, symptom differences were also insignificant. Furthermore, the Thai BCTQ may not be ideal for short–term pain relief studies due to its length and recall bias.

Several limitations occurred during study. First, there was limited research on CTS. There was a lack of extensive studies on the use of rPMS for Carpal Tunnel Syndrome (CTS), highlighting the need for further investigation. Second, there were small sample sizes. The studies conducted so far have had small sample sizes, and larger cohorts could potentially provide clearer and more reliable results. Third, there was protocol duration and follow–up. The duration of the treatment protocols and the need for reexamination after a short course of therapy are areas that require further consideration. Additionally, while we assessed the immediate effects, the potential long–term benefits of the treatment remain to be explored.

Recommendations for Future Studies:

This result is only immediate effect after 1 session of rPMS. Immediate effect alone may not be sufficient to draw conclusions. Future research should explore various rPMS settings to identify the optimal parameters for peripheral nerve stimulation. This will help refine its application for CTS and potentially improve its efficacy.

Conclusions

The treatment using peripheral nerve stimulation with electromagnetic waves in patients with carpal tunnel syndrome (CTS) has not shown efficacy in reducing hand pain or numbness, nor in increasing hand strength when compared to the sham group. Therefore, it cannot yet be considered

a viable option for treating pain and numbness caused by carpal tunnel syndrome.

Disclosure

The authors declare no conflicts of interest.

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