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Effects of Repetitive Peripheral Magnetic Stimulation and Exercise on Pain, Leg Muscle Strength, and WOMAC index in Knee Osteoarthritis Patients

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This study examined the effects of repetitive peripheral magnetic stimulation and exercises on pain, leg muscle strength, and WOMAC index in knee osteoarthritis patients. Twenty subjects were randomly assigned to experimental and control groups. rPMS and exercises were applied to the experimental group for 20 minutes per day, 5 times a week for a total of 4 weeks. The subjects were evaluated by a VAS test, FTSST test, and WOMAC test. In the experimental group, significant decrease was observed in the VAS test after treatment ($p<.05$), and there was significant difference in the VAS test compared to the control group ($p<.05$). In both the experimental group and control groups, significant decrease was observed in the FTSST test and WOMAC test after treatment ($p<.05$), and there was no significant difference in the FTSST test and WOMAC test compared to the control group ($p>.05$). The results of this study suggest that rPMS and exercises applied effects the pain relief and improve knee joint function in knee osteoarthritis patients.

Keywords : repetitive peripheral magnetic stimulation, magnetic field, exercise, pain, leg muscle strength, disability, knee osteoarthritis

1. Introduction

Osteoarthritis is a disease that causes inflammation and pain due to morphological changes and tissue damage of the articular surface due to repeated use and damage of articular cartilage. Knee osteoarthritis is the most common form of osteoarthritis due to weight-bearing, and it is the most common disease among musculoskeletal disorders in the elderly [1]. As aging progresses, the incidence of knee osteoarthritis increases, and according to previous studies, about 80 % of people over 55 years of age and about 95 % of people over 75 years of age had knee osteoarthritis [2]. In other words, as the elderly population increases, the number of patients with knee osteoarthritis is increasing. Knee osteoarthritis usually leads to pain, joint stiffness, decreased range of motion, and decreased leg muscle strength, and causes discomfort in performing activities of daily living and social activities. And there is an increase in disability and loss of functional independence [3].

As such, in clinical practice, methods such as surgery treatment, medicine treatment, exercise therapy, and physical therapy are used to treat knee osteoarthritis. It has been reported that exercise therapy is an important method in the management of knee osteoarthritis [4]. According to previous studies, it has been reported that exercise therapy for knee osteoarthritis patients had various effects such as increase in range of motion, increase in leg muscle strength, and increase in body function, and exercise therapy is recommended for most patients [5]. As such, exercise therapy is a widely used treatment method for patients with knee osteoarthritis, but it has been reported that there are many conflicting studies on the effect of pain control in various studies [6]. Therefore, rather than a fragmentary study that applies independent exercise therapy to patients with knee osteoarthritis, a complex study that applies both physical therapy and exercise therapy effective for pain control is needed.

Among physical therapy methods, Repetitive Magnetic Stimulation (rMS) is a method that repeatedly stimulates magnetic stimulation waves and is effective in enhancing sensory function and motor function. According to a previous study, it was reported that as a result of applying Repetitive Transcranial Magnetic Stimulation (rTMS) to

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knee osteoarthritis patients, it affects the pain neural network and increases the pain threshold as it brings about sensory changes [7]. However, most of the previous studies have investigated the effect of pain control through magnetic stimulation directly on the brain, and studies that conducted magnetic stimulation directly on the peripheral area with pain are lacking. According to previous studies, it was reported that Repetitive Peripheral Magnetic Stimulation (rPMS) can directly stimulate deeper structures non-invasively and is effective for pain control [8]. In addition, magnetic stimulation generates electric current and voltage in the tissue to promote cellular response and has the effect of speeding up the healing rate of bones and tissues [9]. In addition, it has been reported that nerves can be stimulated without direct skin contact, there is no tissue damage due to electricity, and the patient's discomfort is small [10].

Therefore, the purpose of this study was to investigate the effects of rPMS and exercise therapy on pain, leg muscle strength, and disability in patients with knee osteoarthritis. To present the necessary evidence for an effective and objective treatment method for patients with knee osteoarthritis.

2. Materials and Methods

2.1. Participants

This study was conducted on 20 patients who visited the neurosurgery clinic in D city were diagnosed with knee osteoarthritis by a specialist. The specific criteria for selection of subjects are those who can perform intervention according to the researcher's instructions, those who feel pain around the knee joint, those with Kellgren-Lawrence (K/L) of grade 2 or higher of the knee joint on radiological examination, total knee arthroplasty or Those who had not undergone arthroscopic surgery were selected. Patients who are pregnant or lactating, patients who have implanted pacemakers or internal electrical devices, and suspected malignant tumors and thrombosis, were excluded.

The purpose of the study and the contents of the experiment were explained to all study subjects in advance, and voluntary consent was obtained.

2.2. Study design

Twenty patients who met the selection criteria were randomly assigned to each of the Repetitive peripheral Magnetic Stimulation and exercise group (experimental group) and the general physical therapy and exercise group (control group). During the experiment, 9 patients in the experimental group and 8 patients in the control group completed the final experiment except for 3 patients who gave up due to treatment refusal. Evaluation to determine the treatment effect of all subjects was conducted before and after treatment. In addition, all evaluations were conducted in a double-blind, randomized design that did not know any information about patients who were randomly assigned to two groups.

2.3. Intervention

The experimental group received rPMS therapy once a week for 10 minutes for 4 weeks. Neuro MSL magnetic stimulator (MR Inc., Korea) was used as the rPMS treatment device in this study (Fig. 1). Also, round coil is more effective in stimulating deep layer structures such as jonit, and round coil was used in this study. Stimulation site was determined based on patient's most trigger point. And the coil was placed at a flat tangential orientation targeting the most painful knee joint region in supine position. This is the orientation that enables the coil to be positioned parallel to the body surface, thereby maximizing effects of magnetic stimulation applied to the target area. This allows the coil to be positioned parallel to the

Figure 1. (Color online) Repetitive peripheral magnetic stimulation.

Figure 2. (Color online) Montage of rPMS application.

body surface, maximizing the effect of magnetic stimulation on the target area [11, 12]. Each session lasted 10 minutes and entailed an intermittent stimulation protocol consisting of 5 seconds of stimulation at a frequency of 20 Hz followed by 2 seconds of resting. The total number of stimuli over 10 minutes amounted to 1,400 times. The intensity of stimulation was applied at a level that the patient felt comfortable with, and the intensity was gradually increased (Fig. 2). The control group received general physical therapy once a week for 10 minutes for 4 weeks. For general physical therapy, Interferential Current Therapy (ICT) was applied. After each treatment was applied to both the experimental group and the control group, Range of Motion (ROM) exercise and leg strength exercise were performed using a ball, and balance training using a balance pad was performed (Fig. 3). In addition, both the experimental group and the control group applied heat therapy for 20 minutes to relax the muscles before each treatment. The treatment application both groups was conducted by experienced physical therapist.

2.4. Outcome measure

2.4.1. Visual Analogue Scale

Visual Analogue Scale (VAS) was used to determine the pain level of the knee joint. It is a method to indicate the degree of subjective knee joint pain felt by the subject by defining the left end as a very comfortable state without pain and extreme pain at the right end on a 100 mm horizontal ruler. VAS is one of the most widely used methods to measure the degree of pain in clinical practice and is a useful evaluation tool for judging the therapeutic effect [13].

2.4.2. Five Times Sit to Stand Test

The Five Times Sit to Stand Test (FTSST) was used to assess the functional leg strengths of the subjects. This is a test that measures the time of a subject sitting in a chair while performing five sitting actions. The FTSST is a measurement of the independence, recurrence of falls, and status of daily living. It also measures the functional aspects of strength within the lower extremities affected by conditions, such as osteoarthritis [14].

2.4.3. Western Ontario and McMaster Universities

The Western Ontario and McMaster Universities (WOMAC) was first developed as an evaluation tool for outpatient osteoarthritis, and it can effectively evaluate the functional status of the knee joint. WOMAC consists of questions about the subjective functional limitations that patients can feel in daily life related to knee joint pain, and consists of a total of 24 questions, divided into 5 pain items, 2 stiffness items, and 17 body function questions. It is made up of subscales. Each item was evaluated from 0 to 96, with 'None' being 0 points and 'Vert severe' being 4 points, and a higher score means

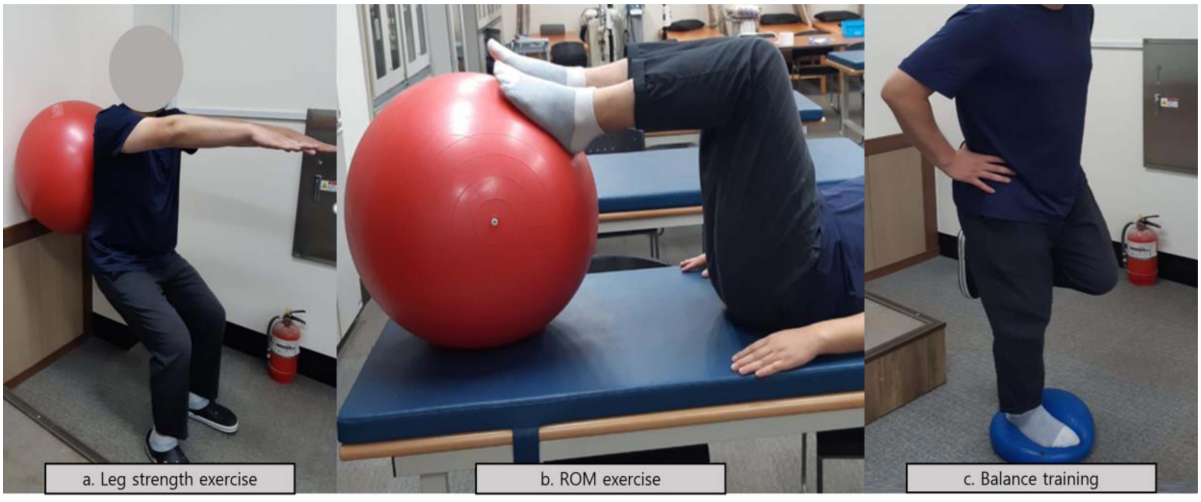

Figure 3. (Color online) Methods of exercise treatment application.

more severe physical dysfunction [15].

2.4. Statistical analysis

A Shapiro-Wilk test was conducted to determine the normal distribution of each measurement item, and all items were normally distributed. The results of the experiments obtained in this study were described as mean ± standard deviation (Mean ± SD). An Independent Sample T-test was performed to examine the differences between groups for the general characteristics of the subjects. Paired T-test was performed to verify the difference before and after treatment within each group, and Independent Sample T-test was performed for comparison between groups. SPSS statistics version 22.0 was used for the data obtained in this study, and the statistical significance level was set to .05.

3. Results and Discussion

Table 1 summarizes the demographics and medical history of the subjects; there were no statistically significant differences between the two groups. The VAS scores showed significant differences after treatment in the experimental group ($p < .05$), but not in the control group ($p > .05$). When comparing the variation between the experimental and control groups, there was a significant difference in the VAS scores ($p < .05$) (Table 2). The results are shown in Fig. 4. The FTSST execution time and WOMAC scores showed significant differences after treatment in both groups ($p < .05$). There was no significant difference as a result of comparing the variation in execution time and WOMAC scores between the groups ($p > .05$) (Table 2). The results are shown in Figs. 5, 6.

The purpose of this study, for four weeks repetitive peripheral magnetic stimulation with exercise therapy were conducted to decrease pain and disability, increase leg strength and functional ability in knee osteoarthritis patients. Each variable was measured before, after treatment to evaluate the effects of repetitive peripheral magnetic stimulation on VAS, FTSST, WOMAC test.

In this study, the VAS was significantly decreased in experimental group, and the VAS was significantly decreased in the experimental group more than in the

Table 1. General characteristics of subjects

	EG	CG
Sex(male/female)	1/8	0/8
Age	71.3 ± 4.78[a]	71.2 ± 3.55
Height(cm)	153.6 ± 9.74	151.7 ± 6.78
Weight(kg)	50.2 ± 8.56	42.4 ± 5.08

[a]Mean ± SD, EG: Repetitive Peripheral Magnetic Stimulation Group, CG: General Physical Therapy Group

Table 2. Comparison of change in variables in each group

Variables	Group	Pre	Post	p
VAS	EG	5.5 ± 0.84[a]	3 ± 0.94	.000*
	CG	6 ± 1.05	5.6 ± 0.69	.309
	p	.258	.000*	
FTSST	EG	20.23 ± 5.86	15.4 ± 4.03	.004*
	CG	20.08 ± 4.57	17.8 ± 1.54	.086*
	p	.949	.096	
WOMAC	EG	54.3 ± 6.83	38.3 ± 4.96	.000*
	CG	52.4 ± 7.42	40.7 ± 5.03	.004*
	p	.559	.297	

[a]Mean ± SD, *$p < .05$, EG: Repetitive Peripheral Magnetic Stimulation Group, CG: General Physical Therapy Group, VAS: Visual Analogue Scale, FTSST: Five Times Sit to Stand Test, WOMAC: Western Ontario and McMaster Universities

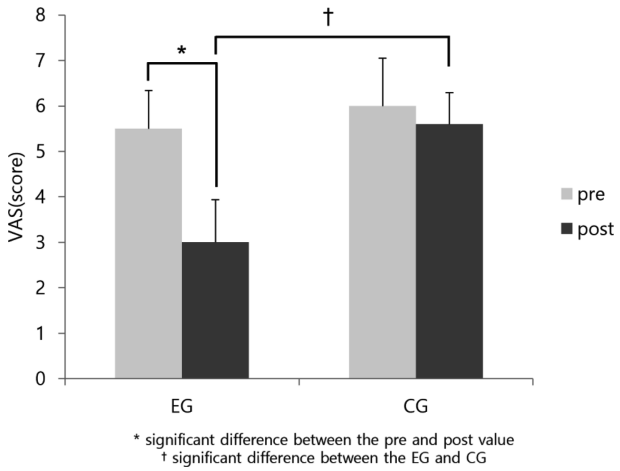

Figure 4. Comparison of pre-value and post value VAS between the groups.

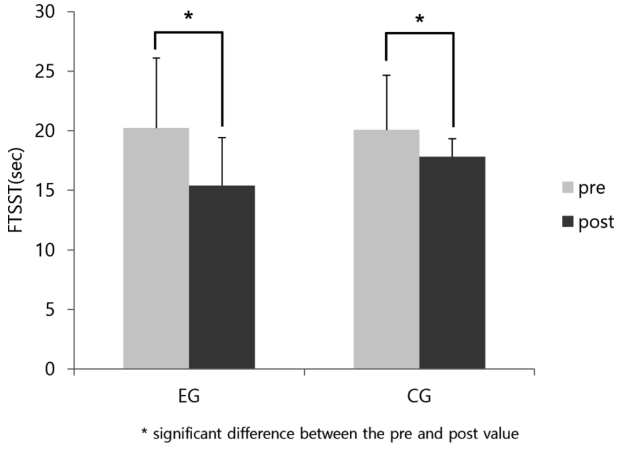

Figure 5. Comparison of pre-value and post value FTSST between the groups.

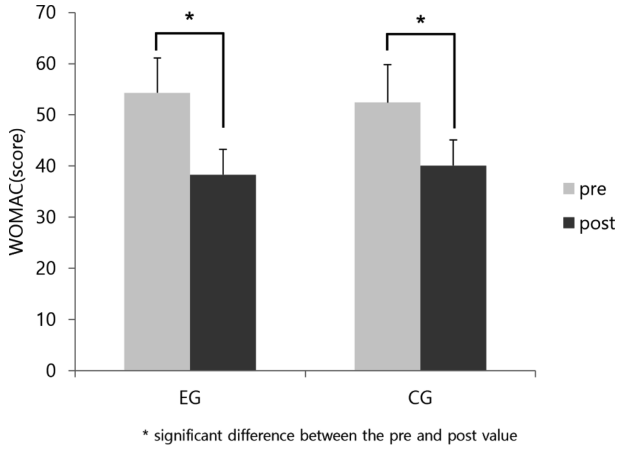

Figure 6. Comparison of pre-value and post value WOMAC between the groups.

control group. According to previous studies, the results of rPMS treatment of knee osteoarthritis patients twice a day for 4 weeks were consistent with the reported results of a significant pain relief [16]. Also, it was consistent with the study results showing that when exercise therapy such as ROM exercise, muscle strength exercise, and balance training was applied to knee osteoarthritis, it was effective in reducing pain [17]. In other words, it was confirmed that the combination of rPMS and exercise therapy was more effective in reducing pain. This research result is the result of gate control theory. The electric field formed by magnetic stimulation can depolarize the large-diameter myelinated Aβ afferent fibers due to the high conduction rate, thereby inhibiting the depolarization of the relatively small diameter Aδ and C nerve fibers, blocking the transfer of pain signals to the brain [18]. In other words, it was confirmed that rPMS are effective in pain relief.

In this study, the FTSST and WOMAC was significantly differenced in both groups, and the FTSST and WOMAC was not significantly differenced in the experimental group and control group. According to a previous study, it was reported that when exercise therapy such as ROM exercise, muscle strength exercise, and balance training was applied to knee osteoarthritis, it was effective in strengthening the muscles of the legs and improving functional disorders [19, 20]. In this study, both the experimental group and the control group included leg strengthening exercises in the exercise therapy program, so it is considered that they were effective in strengthening muscles. Also, in this study, balance training on the balance pad was included in the exercise therapy program. According to a previous study, it was reported that when exercise is performed on an unstable support surface, it has the effect of enhancing the muscles that maintain balance and thus strengthening the function of the joints, resulting in greater activation of the muscles of the legs [21]. That is, it is considered that the execution time of FTSST was reduced in both the experimental group and the control group.

In addition, as an evaluation tool for osteoarthritis, WOMAC can effectively evaluate the functional status of the knee joint. WOMAC includes knee joint pain, stiffness, and body function. In this study, ROM exercise was included in the exercise therapy program for both the experimental group and the control group, and it was effective in improving knee joint stiffness, and it is thought that it was effective in improving the body function of knee osteoarthritis patients through strengthening the legs. Also, there was no statistically significant difference between the experimental group and the control group after treatment, but the WOMAC score was higher in the experimental group than in the control group, which is thought to be because the experimental group to which rPMS was applied was more effective in pain relief. According to a previous study, it was reported that the reduction of internal pressure in the knee joint leads to a decrease in knee joint damage and stiffness in the combined treatment of rPMS and exercise therapy. It has also been reported that magnetic stimulation regenerates joint cells and helps to improve soft tissue around the knee joint, slowing the destruction of knee tissue and protecting it [22]. In other words, it is thought that the stability of the knee joint is improved, and pain and physical disability are reduced.

The limitations of this study are as follows. First, the number of selected subjects was small. In future studies, it is thought that a study involving more subjects is needed. Second, due to the characteristics of outpatients, it is thought that some variables occurred depending on the individual's level of daily life performance in addition to treatment. Third, the duration of treatment was short. In future studies, it is necessary to investigate the effect of quality of life and activities of daily living in patients with knee osteoarthritis by extending the treatment period.

4. Conclusion

To summarize the results of this study, it was found that rPMS and exercise is effective in relieving pain and dysfunction in patients with knee osteoarthritis. Through this study, rPMS and exercise can be suggested as an effective method for non-pharmaceutical and non-surgical treatment of knee osteoarthritis patients. It can also be an effective way to prevent knee osteoarthritis.

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