

Original Article

Effects of Low-intensity Pulsed Ultrasound and Cryotherapy on Recovery of Joint Function and C-reactive Protein Levels in Patients after Total Knee Replacement Surgery

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Abstract. [Purpose] We investigated the effect of low-intensity pulsed ultrasound and cryotherapy on joint function recovery and C-reactive protein (CRP) levels of patients with total knee replacement. [Subjects] Forty-six patients with total knee replacement were recruited and allocated to either low-intensity pulsed ultrasound therapy (n=15), cryotherapy (n=15), or a combination of both (n=16). Therapy was administered once a day, 5 times a week for 3 weeks. To determine functional joint recovery and reduction of inflammation, changes in the Korean Western Ontario and McMaster Universities Arthritis Index (K-WOMAC), range of motion (ROM), and CRP were assessed postsurgically and four times over a 3-week period. Using one-way analysis of variance (ANOVA), homogeneity tests were performed based on participants' general characteristics. To recognize changes in time-variant K-WOMAC, ROM, and CRP values between groups, repeated measures ANOVA was performed, and Tukey's test was used for post-test analysis. Values at $\alpha=0.05$ were considered significant. [Results] We found a difference between groups and times, and the group that received the combined therapies showed greater changes in outcomes than the group that received low-intensity pulsed ultrasound therapy alone. [Conclusion] Applying both low-intensity pulsed ultrasound and cryotherapy can relieve inflammation and enhance joint function in patients who undergo total knee replacement.

Key words: Low-intensity pulsed ultrasound therapy, Cryotherapy, C-reactive protein

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INTRODUCTION

Degenerative arthritis is a frequent disorder, occurring in 65% of senior citizens in Korea. This disorder infiltrates the skeleton and limbs as a progressive or inflammatory lesion that causes loss of function^{1, 2)}. Such cases eventually require total knee replacement surgery to relieve chronic arthritis and restore function of the joint³⁾.

Management of total knee replacement recipients involves physical and mental rehabilitation that aims to improve daily life and sports activities⁴⁾. Specifically, rehabilitation involves pain control and emotional care as well as mobility, attaining maximum joint range of motion, and reinforcement of muscle⁵⁾.

However, deep infections that occur early postopera-

tively are the main reason for pain and functional disorder; these complications of decide prognosis after surgery. Treating patients with these infections increases the cost of postsurgical care because this treatment extends the length of treatment, which is the main factor that impedes smooth rehabilitation⁶⁾. Infection is difficult to diagnose and can persist for 6 months, even in non-infective group⁷⁾. Generally, blood tests measuring C-reactive protein (CRP) levels and Erythrocyte sedimentation rate (ESR) are ordered to trace and determine the efficacy of treatments and to determine prognosis for fever, pain, erythema, and acute pyogenic infection^{8–10)}. In addition, physical therapeutic arthrocentesis for relieving inflammatory symptoms, promoting synovial fluid drainage, and laser therapy are being performed to lower temperature of tissues, and microcurrent therapy and low-intensity pulsed ultrasound therapy are being widely used^{11–14)}.

Saito et al.¹⁵⁾ studied 46 total knee replacement patients who were divided into cryotherapy and control groups. Creatine kinase (CK) and CRP levels were measured before and after treatment; they found that the levels were statistically lower in the cryotherapy group. Hence, lowering tissue temperature can ease pain and aid in tissue recovery

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Table 1. General characteristics of each group

	Group A (n=15)	Group B (n=15)	Group C (n=16)
Age (yrs)	66.6±3.9 ^a	68.5±4.7	67.6±3.5
Height (cm)	155.4±4.7	156.2±4.6	157.1±3.6
Weight (kg)	56.6±3.7	59.1±8.2	58.9±5.1
CRP (mg/dl)	3.8±1.3	3.5±1.0	3.9±1.2
ROM (°)	86.9±7.7	87.1±7.5	88.3±7.0
K-WOMAC (points)	74.1±3.5	74.3±2.7	73.9±1.9

^aMean± SD

Group A: low-intensity pulsed ultrasound therapy group, Group B: cryotherapy group, Group C: low-intensity pulsed ultrasound therapy + cryotherapy group, CRP: C-reactive protein, ROM: range of motion, K-WOMAC: Korean Western Ontario and McMaster Universities Arthritis Index

after surgery. Moreover, Chung et al.¹⁶ triggered synovial inflammation by injecting Freund's of adjuvant and found that low-intensity pulsed ultrasound therapy produced an anti-inflammatory response. Studies on low-intensity pulsed ultrasound and cryotherapy are being conducted; however, studies regarding recovery of joint function and the inflammatory index CRP levels after total knee replacement are lacking. Therefore, our study investigated the effects of low-intensity pulsed ultrasound and cryotherapy on recovery of joint function, pain, and CRP levels in patients who underwent total knee replacement in order to suggest systematic and effective means of managing patients after surgery.

SUBJECTS AND METHODS

The study was authorized by the Institutional Review Board (Number: 2013-01) of Sehan University on September 2, 2013. Participants were recruited from September 2013 to October 2013. Female participants who underwent total knee replacement at M hospital were fully informed about the aim and methods of this study. Participants had no problems in other musculoskeletal and nervous system lesions other than that at the surgical site. Participants were randomly allocated to receive low-intensity pulsed ultrasound therapy (Group A), cryotherapy (Group B), or both treatments (Group C).

Participants consisted of 15 members in Group A, 15 Group B, and 16 Group C; the participants' average ages in each group were 66.6, 68.5, and 67.6 years, respectively. Their mean heights were 155.4, 156.2, and 157.1 cm, and their weights were 56.6, 69.1, and 58.4 kg, respectively. Groups A, B, and C had CRP levels of 3.76, 3.5, 3.88 mg/dl, respectively; and their range of motion (ROM) values were 86.9°, 87.1°, and 88.3°, respectively; their Korean Western Ontario and McMaster Universities Arthritis Index (K-WOMAC) values were 74.1, 74.3, and 74.9 points, respectively. Thus, there were no significant differences in general characteristics ($p>0.05$) among the 3 groups (Table 1).

Patients of all groups were administered CPM for 30 min and TENS for 15 min. Group A was administered low-intensity pulsed ultrasound therapy for 1 min, with 1 MHz, 0.4W/cm² using Care Star GM-002 (Genemedi, Korea). Group B was administered cryotherapy for 5 min using

Crais (Century, Korea), while Group C was administered both therapies. Treatment was administered once a day, 5 times a week for 3 weeks. To assess recovery of joint function and reduction of inflammation, changes in K-WOMAC, range of motion (ROM), and CRP were monitored one day post surgery and measurements were repeated four times for three weeks within a week.

K-WOMAC which was used to assess recovery of joint function, is a self-assessment that consists of questions that index three items: pain level, ankylosis, and degenerative arthritis. K-WOMAC consist of 5 questions for pain (0–20 points), 2 questions for stiffness of joint (0–8 points), and 17 questions for difficulties in daily life (0–68 points). Higher the total points, greater is the severity the knee joints. Joint ROM was measured using a goniometer with the reference point being the line connecting the lateral femoral condyle, greater trochanter, and fibular lateral malleolus when lying face down. CRP levels were tested by collecting 5 cc patient's blood using latex agglutination turbidimetry utilizing monoclonal antibody A15 (Biosystems, Japan).

According to general characteristics of participants, the homogeneity test was performed using one-way analysis of variance (ANOVA). To recognize changes in time-variant K-WOMAC, ROM, and CRP values between groups, repeated measures ANOVA was a performed and Tukey's test was used as a post-test analysis. The statistical significance level was set at 0.05.

RESULTS

The repeated measures ANOVA among the three experiment groups indicated that changes in K-WOMAC values were significantly different in vivo for both time and time×group variance ($p<0.001$ and $p<0.05$, respectively), and that they were significantly different in vitro ($p<0.05$). The post-test analysis showed that Group C had more effective difference than Group A ($p<0.05$). Repeated measures ANOVA indicated a significant difference in vivo ROM changes over time ($p<0.001$), but there was no significant difference in the time×group variance. Furthermore, Tukey's test indicated that changes in ROM were significantly different among the three groups ($p<0.01$). Specifically, Group C showed significantly greater change in ROM than Group A ($p<0.05$). Repeated measures ANOVA indi-

Table 2. Comparison of joint function and C-reactive protein levels among the three experimental groups

Variable	Group	Before	1 weeks	2 weeks	3 weeks	Source ^b	Post-Hoc ^c
K-WOMAC	Group A	74.1±3.5 ^a	66.9±3.0	50.3±2.2	29.0±2.4	T***	
	Group B	74.3±2.7	66.5±2.3	47.5±1.9	29.8±1.7	T×G*	
	Group C	73.9±1.9	66.0±2.3	46.7±2.3	28.7±2.3	G*	C•B>B•A
ROM	Group A	86.9±7.7	102.6±5.6	124.1±4.5	134.4±4.6	T***	
	Group B	87.1±7.5	105.8±8.0	124.8±3.9	138.1±3.5	T×G	
	Group C	88.3±7.0	108.6±6.1	126.4±5.7	140.2±4.4	G**	C•B>B•A
CRP	Group A	3.8±1.3	3.3±1.1	1.8±0.8	0.4±0.1	T***	
	Group B	3.5±1.0	2.3±0.6	1.6±0.7	0.5±0.2	T×G***	
	Group C	3.9±1.2	2.0±0.6	1.3±0.3	0.3±0.1	G*	C•B>B•A

*p<0.05, **p<0.01, ***p<0.001

^aMean±SD, ^bRepeated ANOVA, ^cTukey's test

Group A: low-intensity pulsed ultrasound therapy group, Group B: cryotherapy group, Group C: low-intensity pulsed ultrasound therapy + cryotherapy group, K-WOMAC: Korean Western Ontario and McMaster Universities Arthritis Index, ROM: range of motion, CRP: C-reactive protein, T: Time, T×G: Time×Group, G: Group

cated that changes in CRP values were significantly different in vivo for time×group (p<0.001) as well as among the three groups (p<0.05). Further analysis with Tukey's test found that changes in CRP levels were significantly greater in Group C than in Group A (p<0.05; Table 2).

DISCUSSION

Following total knee replacement, rehabilitation to stabilize the knee joint is accomplished by reducing pain and aiding recovery of muscle strength^{14, 17}. However, inflammatory complications in early stages of rehabilitation can delay improvements, and arbitration for inflammation will reduce metabolism of tissue and enzyme activity, thus leading to relief of symptoms^{18, 19}. Therefore, in order to accomplish successful rehabilitation, management of inflammatory complications is essential.

Our study found significant changes in K-WOMAC, ROM, and CRP after 3 weeks of therapy in all 3 experimental groups, as described previously; our 3 groups low-intensity pulsed ultrasound therapy group, (Group A), cryotherapy group (Group B) and both therapies group (Group C). These significant changes were found within and between groups. However, Group C showed significantly greater differences in K-WOMAC, ROM, and CRP than Group A.

In a study by Kim et al.¹³ wounds created in 20 rats were treated with low-intensity pulsed ultrasound and cryotherapy for 3 days. Wound lengths were assessed; the results showed that low-intensity pulsed ultrasound and cryotherapy heal tissues by activating cells, which is in accordance with the results of our study. The reason is that low-intensity pulsed ultrasound, which is non-thermal energy, changes the density of Ca²⁺ receptors and promotes phosphorylation of proteins according to the cell signal, which the infiltrated through mechanoreceptors. Thus, it can manipulate proliferation of cartilage cells inflammatory reaction²⁰. Cho et al.¹⁴ studied 15 participants who had undergone total knee joint replacement and received ultrasound and microcurrent therapy for 3 weeks and are compared to control group; the results showed that pain and wound recovery rates were

higher in the ultrasound and microcurrent groups than control group. This suggests that pulse ultrasound directly or indirectly heals tissues. Although physiological effects laser therapies are unknown, laser therapy is known to reduce blood flow. Reduced blood flow might reduce edema, inflammation, and hematoma^{21, 22}. Kim et al.²³ found a reduction for ESR for groups receiving cryotherapy and medication for three weeks in patients with acute rheumatoid arthritis. In addition, Lessard et al.²⁴ found that patients who received cryotherapy after knee arthroscopic surgery could perform weight bearing and had reduced reliance on analgesic dosage. Furthermore, Morsi¹¹ found that patients who underwent knee arthroscopic surgery and received cryotherapy experienced less hemorrhage, reduced reliance on pain medications, and improved joint range of motion compared to controls, which is similar to the results of this study. However, the curative effect observed in those who received both therapies was higher than those who received one therapy alone; therefore, combined treatment after total knee replacement may have a higher curative value.

This study is limited in that we did not control activities of patients and their medication regimens (i.e., anti-inflammatory medications); thus, this variability may influence joint function or CRP levels. Nonetheless, the combination of low-intensity pulsed ultrasound and cryotherapy improved rehabilitative outcomes following surgery. Further clinical research of these treatment modalities and outcomes were warranted.

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