



Original Article

## Effects of microcurrent and cryotherapy on C-reactive protein levels and muscle tone of patients with rotator cuff reconstruction

JEONG-IL KANG, PT, PhD<sup>1)</sup>, DAE-KEUN JEONG, PT, PhD<sup>1)</sup>, HYUN CHOI, PT, PhD<sup>2)\*</sup>

<sup>1)</sup> Department of Physical Therapy, Sehan University, Republic of Korea

<sup>2)</sup> Department of Physical Therapy, Mokpo Mirae Hospital: 351 Seokhyeon-dong, Mokpo-si, Jeonnam 530-828, Republic of Korea

**Abstract.** [Purpose] The purpose of the present study was to apply early intervention via microcurrent and cryotherapy in patients who underwent rotator cuff reconstruction surgery, and to investigate the effects of such interventions on pain and inflammation levels based on the analysis of C-reactive protein (CRP) levels, and on changes in muscle tone. [Subjects and Methods] The study population consisted of 30 patients who had undergone rotator cuff reconstruction surgery, with 10 patients each assigned to the control, experimental I (E-I), and experimental II (E-II) groups. On the day after surgery, muscle tone, blood CRP level, and pain were measured. For the following two weeks, continuous passive motion (CPM), icing, cryotherapy, and microcurrent were applied to the each group. After the respective interventions, CRP levels, pain, and muscle tone near the shoulder area were measured again. [Results] In the post-hoc test of between-group comparison, a statistically significant difference in CRP level was found in the cryotherapy group. A difference in shoulder muscle tone appeared only in the supraspinatus muscle, with post-hoc test results showing that the biggest change occurred in the cryotherapy group. [Conclusion] Cryotherapy may be able to help stabilize inflammation as well as reduce pain and muscle tension when applied in patients following rotator cuff reconstruction.

**Key words:** Rotator cuff repair, Cryotherapy, Myotonometer

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### INTRODUCTION

Rotator cuff injury can have a negative effect on shoulder abduction and rotation, as well as on the function that maintains stability in the glenohumeral joint, and can manifest various forms of mechanical damage stemming from a glenohumeral tendon sprain or limited motion, fluid leakage in the surrounding area, and muscle load imbalance<sup>1)</sup>. Various surgical techniques, such as minimally invasive arthroscopic repair, are being performed to treat arthrosis that occurs subsequent to rotator cuff injury, and the development of arthroscopic techniques has resulted in an increasing trend in their use due to easier accessibility to diagnostic and surgical techniques<sup>2)</sup>. These surgical techniques cause pain from deep infection or inflammation, and in particular, arthroscopic shoulder surgery can be accompanied by severe postoperative pain, which may be difficult to control without the use of analgesics<sup>3, 4)</sup>. Analgesics may cause dizziness, vomiting, and sedation, while also failing to adequately control the pain at times<sup>5)</sup>. Inflammatory cytokines that are secreted during inflammation not only stimulate the afferent nerve endings to cause pain, but are also known to have an effect on the degenerative process due to catabolism of the extracellular matrix that comprises the subacromial bursa. Meanwhile, interleukins inside the subacromial bursa (interleukin-1 $\beta$ , IL-1 $\beta$ ) and IL-1 $\beta$  receptor antibodies are known to play an important role in causing shoulder pain<sup>6, 7)</sup>. Physical therapy interventions for the alleviation of inflammatory symptoms that appear early postoperative phase and that promote bone

\*Corresponding author. Hyun Choi (E-mail: pelvic@hanmail.net)

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**Table 1.** General characteristics

Items	C-group (n=10)	E-I (n=10)	E-II (n=10)
	M ± SD	M ± SD	M ± SD
Age (year)	48.1 ± 6.0	46.9 ± 6.1	46.3 ± 5.1
Hight (cm)	169.1 ± 6.7	170.5 ± 7.3	167.8 ± 5.8
Weight (kg)	69.7 ± 6.2	68.5 ± 5.2	67.6 ± 7.8
CRP (mg/dl)	0.45 ± 0.04	0.47 ± 0.03	0.49 ± 0.04

<sup>a</sup>Mean ± SD, Shapiro-Wilk test.

C-group: control group; E-I: experimental group I; E-II: experimental group II; CRP: C-reactive protein.

union and wound healing include icing and cryotherapy to reduce the tissue temperature, in addition to microcurrent and low intensity pulsed ultrasound<sup>8–11</sup>). However, because their efficacies are still debatable, evaluation of such techniques is still in need<sup>12</sup>). Accordingly, the present study applied early intervention via microcurrent and cryotherapy on the day after surgery in patients who underwent rotator cuff repair surgery, as part of an investigation of the effects of such interventions on pain and inflammation levels via C-reactive protein (CRP) measurement, as well as on changes in muscle tone. Moreover, the study also aimed to prove the efficacy of these intervention measures to provide basic clinical data for systematic and effective methods for postoperative patient care.

## SUBJECTS AND METHODS

The present study was conducted over a period of approximately two months, from October 10, 2016 to November 30, 2016. The study was conducted following the reception of approval from the Institutional Review Board at Sehan University (IRB) (Approval number: 2016-13). The study participants were male patients, 40–55 years of age, who had undergone en-masse suture bridge repair for shoulder rotator cuff tear at a medical institution located in South Jeolla Province. The selection criteria included patients who underwent rotator cuff reconstruction surgery following the diagnosis of a partial rotator cuff tear (<3 cm), and who did not have any other musculoskeletal or neurological disorders that may affect the outcomes of the present study. A total of 30 participants who fully understood the contents of the study and who voluntarily signed an informed written consent form were selected for inclusion. The selected participants were divided into three groups of 10 each for the control, experimental I (E-I), and experimental II (E-II) groups, respectively, and on the day after their surgeries, a myotonometer was used to measure their muscle tone around the shoulder area, while their inflammation levels were determined via blood CRP level measurement. CPM and icing were applied to the control group using ice pack; CPM and cryotherapy were applied to the E-I group; and CPM and microcurrent were applied to the E-II group (Table 1). Each intervention was applied six times per week for two weeks, with CPM commonly applied for 20 min; icing applied for 15 min; cryotherapy applied for 30 sec each for four repeated applications; and microcurrent applied for 20 min each with a stimulation setting of intensity of 30–40  $\mu$ A, pulse frequency of 10 Hz, and pulse width of 50 ms. After two weeks of intervention application, CRP levels, pain, and muscle tone near the shoulder area were measured again. All 30 participants complied with an analgesic prescription during the intervention period.

The cryotherapy (Cryo-master; MESH Co., Ltd., Korea) method used in the present study was based on a CO<sub>2</sub> spray method that utilized cryogenic shock waves at  $-78^{\circ}\text{C}$  and 50 bar. The device is used for reducing pain and alleviating inflammation in patients after surgery or during a period of high inflammation. The microcurrent (MC PLUS; Cybermedic Co., Ltd., Korea) technique used a portable device with two attachable carbon electrodes; the therapy was applied following the application of gel to facilitate current delivery to the skin.

Muscle tone was measured by using Myoton<sup>®</sup> PRO (Myoton AS, Tallinn, Estonia) on the upper trapezius and SCM. Myoton<sup>®</sup> PRO is able to diagnose muscle characteristics in simple and non-invasive manner, and provides highly reliable data with intra-rater reliability correlation coefficient of 0.94–0.99<sup>13, 14</sup>). With the participant seated in a chair with back support, the probe of the Myoton PRO device was placed vertically on the area around the supraspinatus and infraspinatus muscles to measure tone (Hz), elasticity (log decrement), and stiffness (N/m). With respect to the measurement method, the skin was pressed down with a force of 0.18 N; 0.4 N of impulse was then applied instantaneously for a total of five times in 15 ms intervals<sup>15</sup>). Subsequently, skin surface vibration caused by the Myoton<sup>®</sup> PRO device was measured to confirm the mechanical parameter values. Measurements were repeated three times in 15 s intervals, and the mean value of the repeated measures was recorded.

Following the collection of 5 cc of blood from each patient, CRP was tested by monoclonal antibody-based latex agglutination test using the A15 analyzer (Biosystems SA, Barcelona, Spain). Moreover, a visual analog scale (VAS) developed by Scott and Huskisson<sup>16</sup>) was used to assess the level of subjective pain in participants.

SPSS 18.0 for Windows (IBM Corp., Armonk, NY, USA) was used for data analysis. Normality of the general characteristics of participants, and group CRP levels were tested by using the Shapiro-Wilk test. A two-way ANOVA was used for between-group comparisons, while the Tukey test was used for post-hoc analysis. The significance level was set to  $p=0.05$ .

**Table 2.** Comparison of change between groups on C-reactive protein (unit: mg/dl)

Groups	Pre-test	Post-test	Post-hoc
	M ± SD	M ± SD	
C-group	0.45 ± 0.04 <sup>a</sup>	0.37 ± 0.03	* C,EII<EI
E-I	0.47 ± 0.03	0.28 ± 0.06	
E-II	0.49 ± 0.04	0.39 ± 0.02	

\*p<0.05.

<sup>a</sup>Mean ± SD, ANCOVA.

C-group: control group; E-I: experimental group I; E-II: experimental group II.

**Table 3.** Comparison of change between groups on Myotone

Items	Muscle	Group	Pre-test	Post-test	Post-hoc
Tone (Hz)	Supra supinatus	C-group	18.0 ± 1.7 <sup>a</sup>	16.9 ± 2.0	* C,EII<EI
		E-I	18.8 ± 1.8	15.9 ± 1.4	
		E-II	18.1 ± 1.6	16.9 ± 1.9	
	Infra spinatus	C-group	12.6 ± 1.2	10.1 ± 1.4	
		E-I	11.7 ± 1.4	9.1 ± 1.8	
		E-II	12.0 ± 1.6	10.8 ± 1.5	
Elasticity (Log decrement)	Supra supinatus	C-group	0.3 ± 0.1	0.5 ± 0.2	
		E-I	0.4 ± 0.2	0.5 ± 0.2	
		E-II	0.4 ± 0.2	0.5 ± 0.2	
	Infra spinatus	C-group	0.3 ± 0.1	0.3 ± 0.1	
		E-I	0.3 ± 0.1	0.4 ± 0.04	
		E-II	0.2 ± 0.03	0.4 ± 0.1	
Stiffness (N/m)	Supra supinatus	C-group	316.2 ± 28.1	274.2 ± 25.9	
		E-I	335.8 ± 29.1	278.0 ± 27.3	
		E-II	329.0 ± 27.6	281.8 ± 24.9	
	Infra spinatus	C-group	173.1 ± 15.6	152.2 ± 19.8	
		E-I	188.2 ± 14.8	158.2 ± 18.0	
		E-II	181.5 ± 13.9	160.3 ± 17.0	

\*p<0.05.

<sup>a</sup>Mean ± SD, ANCOVA.

C-group: control group; E-I: experimental group I; E-II: experimental group II.

**Table 4.** Comparison of change between groups on VAS (unit: point)

Groups	Pre-test	Post-test	Post-hoc
	M ± SD	M ± SD	
C-group	66.2 ± 4.5 <sup>a</sup>	40.4 ± 5.2	
E-I group	63.3 ± 3.3	39.2 ± 4.5	
E-II group	61.2 ± 0.04	41.5 ± 5.3	

<sup>a</sup>Mean ± SD, ANCOVA.

VAS: visual analogue scale; C-group: control group;

E-I: experimental group I; E-II: experimental group II.

## RESULTS

In the present study, post-hoc test results from between-group comparisons showed that the cryotherapy group had the largest change in CRP levels (p<0.05; Table 2). With regards to shoulder muscle tone, a difference in muscle tone was found only in the supraspinatus muscle, with post-hoc test results showing the largest change being present in the cryotherapy group (p<0.05; Table 3) (Table 4).

## DISCUSSION

With respect to the icing, cryotherapy, and microcurrent techniques that are applied for the purpose of reducing postoperative inflammation in clinical settings, the present study applied these techniques in the early rehabilitation process of patients who had undergone rotator cuff repair surgery, in order to investigate their effects on the reduction of inflammation as shown by changes in CRP levels, along with related muscle tone changes. For this purpose, interventions were applied for two weeks to 30 participants who had undergone rotator cuff repair, and pre- and post-hoc tests were performed.

Inflammatory complications that occur during the early stage of postoperative rehabilitation can slow down aggressive rehabilitation, while proper intervention in the inflammation process early on can relieve symptoms by causing reduced tissue metabolism and enzyme activities<sup>17, 18</sup>.

Speer et al.<sup>19</sup>) divided 50 shoulder surgery patients into experimental and control groups to test the efficacy of cryotherapy, and found that the application of cryotherapy led to the patients sleeping better at night and demonstrating less injuries during the rehabilitation period, which were attributed to the reduction in pain and swelling.

Murgie and Cassard<sup>20</sup>) reported that simultaneously applying cryotherapy and dynamic intermittent compression on anterior cruciate ligament reconstruction patients resulted in a reduced use of analgesics and in improved knee function. Lessard et al.<sup>21</sup>) also reported that patients who underwent cryotherapy following arthroscopic knee surgery were able to show early weight-bearing and a reduced use of analgesics. A study by Kang et al.<sup>22</sup>) also reported that the combined application of cryotherapy and pulsed ultrasound on total knee arthroplasty patients resulted in a significant difference in CRP levels, showing a positive effect on the aspects of pain, function, and inflammation relief.

In the post-hoc test involving between-group comparisons, the cryotherapy group showed a statistically significant change in CRP levels, which supported the results of previous studies. Notably, some studies have suggested that reduced joint temperature due to continuous cryotherapy after surgery may stimulate the activities of proteolytic enzymes, which can have a negative impact on the cartilage of joints, while others have recognized its efficacy for non-pharmacological pain suppression and explained that this was a basic pain suppression mechanism from reduced tissue temperature<sup>23</sup>). Moreover, the reason why the findings were contrary to those achieved with the use of an ice pack, which is based on the same temperature mechanism, can be explained by the therapeutic mechanism of cryotherapy used in the present study. Highly pressurized gas yielding low temperature therapy takes away nearby heat through a process that deposits solid dioxide (dry ice) that turns white when liquid carbon is applied to the skin. The amount of heat absorption through this process is larger than the amount of heat absorption activated through convection with an ice pack, while also causing a rapid decrease in skin temperature<sup>24</sup>). Moreover, a skin temperature of  $\leq 13.6$  °C is needed to induce local pain, while nerve conduction velocity is reduced at  $\leq 12.5$  °C<sup>25</sup>), and a tissue temperature decreased to 10–11 °C can reduce metabolic enzyme activities<sup>26</sup>). A sudden temperature change that occurs in this manner can increase the activities of the sympathetic nerves, and such activities of the sympathetic nerves regulate inflammation and the release of cytokines. Moreover, there is a theoretical background that states that association with the sympathetic nervous system is important for treating inflammation, and thus, attention should be paid to this aspect<sup>27</sup>). Kim et al.<sup>28</sup>) indicated that if the value for muscle tone is high among the various measured elements of a myotonometer, then an increased level of pain or exercise overload would appear. Shoulder muscle tone in the present study also showed a difference only in the supraspinatus muscle, and post-hoc test results showed that the biggest change occurred in the cryotherapy group. It is believed that such a decrease was the result of a reduced inflammatory response from the protective reflex contraction of the muscles surrounding the shoulder, which may be attributed to the anti-inflammatory mechanism of cryotherapy.

Based on the findings in the present study, it was confirmed that cryotherapy can help reduce pain and muscle tension by stabilizing the inflammation process following rotator cuff reconstruction. However, the present findings cannot be generalized because the study considered patients from only a single medical institution, the study period was short, and the patients' different activities of daily living were not adequately controlled. Moreover, the theoretical background on the therapeutic effects of cryotherapy has not yet been firmly established, and still remains under debate. Therefore, it is believed that future prospective studies that take into consideration the various aspects, with changes to the duration of treatment and application methods, are needed.

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