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Original Article

Effects of extracorporeal shock wave therapy on upper extremity muscle tone in chronic stroke patients

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Abstract. [Purpose] The purpose of this study was to examine the effects of extracorporeal shock wave therapy (ESWT) on upper extremity muscle tone in chronic stroke patients. [Subjects and Methods] For this study, 30 stroke patients participated in this study and they were divided into ESWT group and sham-ESWT group, each group consisted of 15 patients. ESWT and sham-ESWT was performed by the patients for two times a week, for eight weeks. MyotonPRO was used to measure muscle tone. [Results] According to the results of the comparisons between the groups, after intervention, upper extremity muscle tone was significantly lower in the ESWT group than in the sham-ESWT group. [Conclusion] This study showed that ESWT is effective for improving decrease of muscle tone in chronic stroke patients.

Key words: Stroke, Muscle tone, ESWT

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INTRODUCTION

Stroke, caused either by a blockage or a rupture of a blood vessel in the brain, is characterized by various clinical manifestations, including neurologic deficits, sensory disturbances, motor disturbances, and cognitive impairment[1, 2)]. Among these, spasticity is the most common post stroke neurologic complication, manifesting as a velocity-dependent increase in stretch reflex[3)]. Spasticity causes changes in muscle properties and increases their elastic viscosity, which in turn induces muscle stiffness and weakness, leading to restrictions in activities of daily living[4, 5)].

Commom management of spasticity consists of passive stretching, splints, drug, phenol injection and botulinum toxin (BTX) injection. However, current treatment of spasticity in post-stroke survivors are often unsatisfactory[6)]. In recent years, studies have reported that ESWT is a safe, noninvasive, alternative treatment for spasticity that does not cause muscle weakness or unpleasant effects in patients with multiple disease of central nerve system[7, 8)].

Extracorporeal shock wave therapy (ESWT) is used to promote cellular generation and to reduce pain by boosting local neovascularization and growth factor expression, with the energy specifically focused on the affected area[9)]. It is also effective in treating patients with upper motor neuron syndrome and accompanying hypertonia, given its efficient ability in reducing muscle tone and in improving range of motion of joints, neurotransmission velocity, and muscle strength[10, 11)].

At this time, many studies are actively underway or have recently been conducted on ESWT. However, most of these studies are focused on musculoskeletal disorders, and the investigation of ESWT in the context of neurological diseases accompanied by hypertonia is still lacking. This current study therefore aimed to investigate the effects of ESWT on upper extremity muscle tone in stroke patients with muscle hypertonia and to provide valuable data for developing stroke rehabilitation programs.

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Table 1. Characteristics of the subjects

	Group I (n=15)	Group II (n=15)
Male/Female	9/6	10/5
Age (yrs)	64.2 ± 5.1	65.0 ± 4.8
Height (cm)	162.4 ± 8.1	163.7 ± 7.7
Weight (kg)	60.8 ± 9.4	61.3 ± 8.5
Stroke type (Infarction/Hemorrhage)	10/5	9/6
Paretic side (Left/Right)	9/6	9/6
Duration (months)	18.1 ± 7.2	16.9 ± 7.7
MMSE-K (sores)	25.6 ± 1.0	25.4 ± 1.2
MAS (grades)	1.4 ± 0.7	1.5 ± 0.4
FMA (scores)	27.4 ± 9.8	26.9 ± 9.1

MMSE-K: mini mental state examiation-Korea; MAS: modified Ashworth scale; FMA: Fugl-Meyer assessment.

SUBJECTS AND METHODS

This study was approved by Bioethics Committee of Sehan University Center (IRB) (Approval number: 2016-8) on August 1, 2016. This study included 30 patients who had been hospitalized due to post-stroke hemiplegia. All of the study subjects met the inclusion criteria, which included 1) stroke diagnosed at least six months ago; 2) ability to communicate with scores of 24 or higher in the Korean version of the mini-mental state examination; 3) hypertonia with 1–2 modified Ashworth scale levels; 4) no severe contracture of the elbow and wrist; and 5) no other medical conditions (internal medicine or surgical). Subjects were excluded if they had undergone botulinum toxin or phenol injection in the last three months, and any medication administration status or dose that could influence spasticity remained unmodified (Table 1). The subjects of this study were randomly selected into ESWT group (Group I) and sham-ESWT group (Group II). General physical therapy was conducted including development therapy for the central nervous system before ESWT and sham-ESWT.

The JEST-2000 (JOEUN Medical, Dae-Jeon, South Korea) was used for the ESWT. The ESWT were focused in the flexor hypertonic muscle of the forearm and the interosseous muscles of the hand: 1,500 shots were used to treat flexor muscles of the forearm mainly in the middle of the belly, and 3,200 shots for interosseous muscles of the hand (800 for each muscle). The energy applied was 0.03 mJ/mm^2. Placebo treatment (sham-ESWT) without shock wave energy was applied with the same instrumentation, and the same sound was used in all patients. The ESWT was performed over the flexor carpi ulnaris and radialis, and over intrinsic muscles and flexor digitorum tendon of the hand[12)]. ESWT and sham-ESWT was performed by the patients for two times a week, for eight weeks.

Mechanical properties of muscles, such as tone, stiffness, and elasticity, were measured using the MyotonPRO (Myoton AS, Tallinn, Estonia). The tone of the flexor carpi ulnaris and radialis as well as the flexor digitorum was measured with the patient in a supine position to minimize the influence of posture on muscle tone[13)].

Fugl-Meyer Assessment (FMA) assesses motor function recovery after stroke and consists of 33 and 17 performance items in the upper and lower limbs, respectively. The scores range from 0 (unable to perform), to 1 (partial ability to perform), to 2 (near normal ability to perform). The item that measure wrist control and hand function have been revealed to have excellent intra rater reliability and high interrater reliability[14)].

A Window SPSS ver 18.0 statistical software was used for analysis of the results of this study. Descriptive statistics were used for the characteristics of subject, and analysis of covariance (ANCOVA) was conducted to examine the difference in upper extremity muscle tone before and after the intervention between groups. Statistical significance level was $\alpha=0.05$.

RESULTS

According to the results of comparisons between the groups after the intervention, the change of mechanical properties of FCU and FCR, FD was significantly bigger in the group I than in the group II ($p<0.05$) (Table 2).

DISCUSSION

The aim of this study was to identify the effects of ESWT on mechanical properties of muscles and motor skills in stroke patients. ESWT has already been applied for a variety of purposes in many clinical settings, such as to reduce pain and to increase joint range of motion and neurotransmission velocity[15)].

Moon et al.[16)], compared changes in muscle tone before and after ESWT intervention in 30 subacute stroke patients, and reported significantly decreased muscle tone in the lower extremities. Li et al.[17)] performed ESWT in 60 stroke patients

Table 2. Comparison of mechanical properties of muscle

		Group I (n=15)		Group II (n=15)	
		Pre	Post	Pre	Post
FCU	Tone (Hz)	15.8 ± 3.6	10.4 ± 3.7*	16.1 ± 4.0	14.8 ± 3.3
	Stiffness (N/m)	324.9 ± 35.9	300.8 ± 31.5*	327.4 ± 32.9	319.2 ± 36.1
	Elasticity (Log decrement)	1.3 ± 0.6	1.0 ± 0.2*	1.4 ± 0.2	1.3 ± 0.6
FCR	Tone (Hz)	14.9 ± 4.2	9.8 ± 3.7*	15.2 ± 3.6	13.5 ± 2.6
	Stiffness (N/m)	332.8 ± 40.4	314.2 ± 32.6*	334.4 ± 39.6	324.7 ± 32.9
	Elasticity (Log decrement)	1.4 ± 0.5	1.1 ± 0.3*	1.5 ± 0.9	1.4 ± 0.6
FD	Tone (Hz)	17.6 ± 2.9	11.9 ± 3.1*	18.2 ± 3.6	16.4 ± 4.2
	Stiffness (N/m)	340.7 ± 33.6	318.2 ± 29.9*	341.2 ± 36.3	330.4 ± 32.2
	Elasticity (Log decrement)	1.6 ± 0.4	1.4 ± 0.5*	1.6 ± 0.5	1.5 ± 0.8

Valuse are show as the mean ± SD.
Significant difference between the two groups *$p<0.05$.
Group I: ESWT; Group II: sham-ESWT; FCU: flexor carpi ulnaris; FCR: flexor carpi radialis; FD: flexor digitorum.

who were divided into a three-session ESWT group, single-session ESWT group, and placebo ESWT group, and found a significant increase in the Fugl-Meyer Assessment scores of the upper extremities in the three-session group. The results of this study also showed significant change in the mechanical properties of the muscles following ESWT, when compared with those of the placebo ESWT group, in line with the findings of previous studies, although the area to be treated and the duration of illness in this study differed from those in those other studies. Therefore, this study provides support for the effectiveness of ESWT in reducing muscle tone.

Fröhlich-Zwahlen et al.[18] stated that stroke patients experience changes in the mechanical properties of their muscles and that stiffness, tone, and elasticity show higher levels of reliability and validity when compared with muscle tone as measured with the modified Ashworth scale (MAS). They also found significant differences in these mechanical properties between the high and low muscle tone groups. Amelio and Manganotti[19] reported a significant reduction in MAS levels following ESWT in 12 patients with cerebral palsy who were divided into an ESWT group and a placebo ESWT group, respectively.

In this study, the ESWT group (Group I) demonstrated significant differences in stiffness, tone, and elasticity, showing different mechanical characteristics from those of the control group (Group II). That is, this study confirmed a significant reduction in muscle tone following ESWT intervention in patients with muscle hypertonia, in line with previous findings in the literature, although the underlying diseases in the current study and previous ones are different from each other. ESWT is considered to reduce muscle tone and to change the mechanical properties of spastic muscles in stroke patients by altering the rheological properties of thixotropic tissues, where fibrosis was reduced and blood vessels were reformed.

This study is limited by a small sample size and by the specific physical region covered by the research, making it difficult to generalize the results. This study confirmed the effectiveness of ESWT in improving the mechanical properties of muscles and motion skills in stroke patients. Nonetheless, further studies are necessary to investigate how ESWT could influence upper extremity muscle activity and daily life activities in stroke patients.

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Conflict of interest

None.

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