

Effect of Russian Current Stimulation on Muscular Performance and Muscle Activity of Quadriceps Femoris Muscle of Convalescent Patient after Leg Fracture

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러시안 전류 자극이 하지 골절 후 회복기 환자의 넙다리네갈래근육의 근수행력과 근활성도에 미치는 영향

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Abstract The present study was aimed to comprehend the effect of the Russian current stimulation on the muscular performance and activity of quadriceps femoris muscle of the convalescent patient after the leg fracture. This study conducted test based on 20 patients after leg fracture. Russian current was applied for six weeks as three times in a week, between January 9, 2013 and 15 March 16, 2013. The electromyogram was used to measure the muscle activity of the quadriceps femoris, and the isokinetic equipment was used to measure the muscular performance. The muscular performance difference by duration depending on the application of the Russian current showed the significant increase in all muscular performances. The activity of all muscles of the quadriceps femoris muscle by duration showed significant increase. These results showed that the Russian current can be the effective treatment method for enhancing the muscular strength of the weakened lower limbs muscle due to the problem such as the leg fracture.

Key Words : Leg fracture, Russian current, Muscular performance, Muscle activity, quadriceps femoris

요약 본 연구에서는 하지 골절 후 회복기 환자에게 러시안전류 자극이 넙다리네갈래근의 근수행력과 활성도에 미치는 영향을 알아보기 위하여 실시하였다. 본 연구는 2013년 1월 9일에서 2013년 3월 16일까지 실시하였으며, 하지 골절 후 회복기에 있는 환자 20명을 대상으로 실험을 실시하였다. 러시아 전류자극기의 큰 도자를 넙다리네갈래근의 근위부에 위치하고, 작은 도자는 원위부에 부착시키고 한 주에 세 번, 6주 동안 적용하였다. 대상자의 넙다리네갈래근의 근활성도를 측정하기 위해 근전도가 이용되었고, 근수행력을 측정하기 위해 등속성기기가 이용되었다. 연구 결과 기간별 넙다리네갈래근의 근수행력 차이는 러시안전류 치료 전과 비교하여 4주 후와 6주 후에서 유의한 근수행력의 증가를 나타내었다. 또한 넙다리곧은근, 안쪽넓은근, 가쪽넓은근의 근활성도는 치료 전과 비교하여 4주 후와 6주에서 유의한 증가를 나타내었다. 이와 같은 결과는 러시안 전류가 하지 골절 등과 같은 문제로 인해 약화된 하지 근육의 근력 강화를 위해 선택될 수 있는 효과적인 치료 방법이라 할 수 있다.

주제어 : 하지골절, 러시안전류, 근수행력, 근활성도, 넙다리네갈래근

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1. Introduction

The muscular strength must be decreased due to damage or disease, so to recover each individual normal muscular strength caused by damage or disease is essential. As the method to improve the muscular strength, there are the method using voluntary contraction and the method using the contraction by the electric stimulation, and the muscular contraction by the electric stimulation brings the muscular strength improvement similar with muscular contraction by the voluntary isometric exercise[1,2].

There are electrical muscle stimulation and neuromuscular electrical stimulation to improve the muscular function, and the neuromuscular electric stimulation(NMES) or functional electrical stimulation(FES) are used for the electric stimulation of the normal neurarchy muscle[3]. Especially, NMES can improve the healthy normal muscle and muscle function which may be decreased due to the pathological factor[4].

Johnson et al reported that the increase of muscular contraction through the electric stimulation by the active isometric exercise[5], Kots reported that the muscular strength of the athlete in the former Soviet Union by implying 2,500 Hz current which can generate 50% duty cycle and 50 Hz burst modulation frequency in the study using Russian current, and the maximum muscle torque showed the optimal muscular strength reinforcement effect by the "10/50/10" treatment prescription(resting for 50 sec, stimulating for 10 seconds, repeating for 10 minutes)[6].

In recent years, as the portable stimulation therapy facility was propagated, it is used in the hospitals and homes widely, so many studies by the current type, ripple mark, frequency, duty cycle were reported[7], and the electric stimulation using this can cause the continuous and strong muscular contraction[8].

The application pattern of the nerve root electric stimulation changes depending on the purpose of

treatment, and it can be applied for the muscular strength promotion or promotion of endurance[9]. So in this study, it is aimed to comprehend the effect of the Russian current stimulation on the muscular performance and activity of quadriceps femoris muscle of the convalescent patient after the leg fracture, and it is expected to be used as the necessary data to determine the best muscular contraction condition by the applied stimulated condition in this study.

2. Method

2.1 Subject and duration of the study

This study conducted test based on 20 convalescent patients after leg fracture in G areas in North Gyeongsang Province. Before the test, the purpose of this study was explained to the subjects and the agreement of participation was received, and the test was conducted from Jan. 9 until March. 16 2013.

2.2 Test tools and measurement method

In the condition that the subjects are sitting, the round pillow was put under the knee joint to maintain the 30 degrees of knee flexion, and the big catheter was positioned in the proximal part of quadriceps femoris muscle by using the Russian current stimulator(ENRAF, ENDOMED 982, Netherlands) as the test tools, and the small catheter was attached in the distal part. The stimulated condition of Russian current was set as 2500 Hz pulsation frequency, unexpected ripple mark, pulsation duration 400 us, pulse rate 50 pps. On-off ratio was 1:4 as stimulating for 10 sec and after that, resting for 40 sec, and the intensity was applied in the limit that the patients can

Table 1. General characteristics of subjects (Mean±SD)

Subject	Age(year)	Height(cm)	Weight(kg)
Male(n=14)	38.70±3.82	172.00±3.01	71.30±4.08
Female(n=6)	41.70±3.11	161.10±3.07	52.70±2.54

Table 2. Change of muscle performance on quadriceps femoris (Mean±SD)

	Pre-test	2 weeks	4 weeks	6 weeks
Peak torque(Nm)	44.03±27.77	63.17±24.59	79.82±26.22	81.31±24.15
Peak torque/ Body weight(%)	62.1±34.5	94.87±36.2	119.39±34.89	122.22±32.58
Total work(J)	204.87±162.36	305.25±125.01	421.49±172.67	326±182.06
Average power(W)	47.82±43.03	86.27±35.92	112.94±45.85	83.52±31.25
Agonist vs Antagonist ratio(%)	35.67±17.31	37.63±8.14	41.06±9.4	36.38±5.58

Table 3. Tests of between-subjects effects on muscle performance

	Type III SS	df	MS	F	p
Peak torque(Nm)	19138.585	3	6379.528	21.717	0.000*
Peak torque/ Body weight(%)	48982.575	3	16327.525	22.388	0.000*
Total work(J)	497325.869	3	165775.290	13.014	0.000*
Average power(W)	45062.913	3	15020.971	16.597	0.000*

*p<.05, The results was repeated measure ANOVA

Table 4. Variation of quadriceps femoris RMS score within application period (Mean±SD)

	Pre-test	2 weeks	4 weeks	6 weeks
Rectus femoris	158.06±50.06	230.95±95.57	235.91±95.57	275.95±123.19
Vastus medialis	114.09±1570.65	1240.09±1829.37	79.70±63.20	112.06±126.73
Vastus lateralis	112.27±46.93	161.80±67.01	185.34±70.15	214.54±84.93

Table 5. Tests of between-subjects effects on quadriceps femoris

	Type III SS	df	MS	F	p
Rectus femoris	151808.575	3	50602.858	9.877	0.000*
Vastus medialis	25345417.313	3	8448472.438	5.613	0.002*
Vastus lateralis	117823.441	3	39274.480	24.253	0.000*

*p<.05, The results was repeated measure ANOVA

endure, it was applied for six weeks as three times in a week. The catheter was attached in the origin part of

the rectus femoris and another one was attached in the lateral/medial intermedius. A pair of catheter was attached in the insertion part and the catheter on the far side was attached in the knee ligament as the quadriceps femoris muscle common tendon. The current intensity increased slowly as much as causing the visible muscular contraction, and it was selected for the subjects can endure.

The electromyogram(Telemyio 2400T G2, Noraxon, USA) was used to measure the muscle activity of the quadriceps femoris muscle, and the isokinetic equipment(Biodex system 4, USA) was used to measure the muscular performance. The catheter for the electromyogram(EMG) was attached on the rectus femoris, lateral/medial intermedius muscle region to be connected to EMG. The grounding electrode was attached on the lateral supracondylar ridge of the quadriceps bone. In addition, the Biodex system as the isokinetic equipment was used to measure the muscular strength of the right quadriceps femoris muscle as the dominant leg. The angular speed of isokinetic apparatus was set as 60 degree/sec, and one set is that the knee joint flexion and extension will be repeated for adapting to this exercise, and it will be repeated five times in the maximum force and resting for 30 sec. and total two sets were measured and the average value was used. The measured value used Biodex Advantage Software(V.4X) program to analyze the performance of the quadriceps femoris muscle.

2.3 Analysis method

The measured value used PASW(windows ver. 18.0) for the statistical process. To examine the difference muscular strength change by the duration, the repeated measured ANOVA was conducted, in the significant case, the contrast test was conducted to examine the significance by duration and before the test. The level of significance α for the statistical verification was 0.05.

3. Result

3.1 General property of the subject of study

The participants of this study were total of 20 leg fracture patients, the gender was 14 males and 6 females, and the average age was 38.70 ± 3.82 for the male and 41.70 ± 3.11 for the female. The height was 172.00 ± 3.01 for the male and 161.10 ± 3.07 for the female, and the weight was 71.30 ± 4.08 for the male and 52.70 ± 2.54 for the female (Table 1).

3.2 Performance change of quadriceps femoris muscle by Russian current application

The muscular performance difference of quadriceps femoris muscle by duration depending on the application of Russian current is as Table 2. In the result of the contrast test by treatment period, all muscular performances was compared with before and after treatment, so the increase of the significant muscular performance after 4 weeks and 6 weeks was shown ($p < .05$).

3.3 Activity change of quadriceps femoris muscle muscular by Russian current application

The muscular activity difference of quadriceps femoris muscle by duration depending on the application of Russian current is as Table 4. In the result of the contrast test by treatment period, the muscle activity of the rectus femoris, medial intermedius and lateral intermedius showed the significant increase after four and six weeks comparing to before the treatment ($p < .05$).

4. Discussion

The application pattern of the nerve root electric stimulation changes depending on the purpose of

treatment, and it can be applied for the muscular strength promotion or promotion of endurance by changing variously the parameters such as the current, ripple mark, pulsating frequency, on-off ratio, electrode placement, stimulus intensity difference etc[9]. About the application pattern of Russian current in this study, Delitto said that 35-50 pps frequency can induce the strong axis by activating all motor units, so 50 pps frequency was used in this study[10]. The stimulus intensity and on-off ratio are related to the muscle fatigue by the electric stimulation, and the topical muscle fatigue means the physiological phenomena that the muscle reaction decreases due to decrease of motor unit. The stimulus intensity was judged that can make 60% or 70% maximal voluntary contraction(MVIC)[11], and Laufer et al asserted that the muscle strength of more than 30~50% MVIC is needed to obtain the muscular strength by the electric stimulation[12], in this study, it was applied in the range that the patients can endure by considering the clinical usefulness. The on-off ratio was stimulated for 20 minutes as 1:4, and the muscle fatigue was minimized when the on-off ratio was stimulated as 1:5, and it showed more excessive muscle fatigue as 1:3 than 1:5 or 1:7, and that report was used[13]. In other words, the decisive factor of muscle fatigue for the electric stimulation is by the amount of muscular contraction[14], so application with 1:4 ratio as the middle of 1:3 and 1:5 is judged as the available stimulated condition for the muscular performance improvement, so the muscular performance and muscle activity of the quadriceps femoris muscle significantly increased[15].

The Russian current is used for enhancing muscle[15], the muscular fiber by the electric stimulation is used in Type II as Type I oppositely with the voluntary contraction[16]. According to Hudlicka et al, the property of muscular contraction changes by long-term electric stimulation with low frequency in Type II b type fiber, and these changes are related to the stimulus duration[17,18], so if the long-term

low-frequency current is applied for more than two weeks in minimum, it will change physiologically into I type fiber. This study conducted 18 times electric stimulation for six weeks to examine the effect of the Russian current stimulation on the change of the muscular performance and muscle activity of the quadriceps femoris muscle of the convalescent patient after having a leg fracture, it was confirmed that the muscular performance and activity significantly increased from after four weeks of treatment, and it can be judged as same results with the result by Romero et al[18] that the isometric strength increased with 31% in non-dominant leg(non-dominant leg) and 21% in dominant leg(dominant leg) by applying NMES to the quadriceps femoris muscle of the healthy subjects for five weeks and the result by Laughman et al[19] that the muscular strength significantly increased by stimulating the quadriceps femoris muscle with the Russian current for five weeks. This study is one of the experiments conducted by the limitations of the target group has got the next wave of Russians and other electrical therapy research is needed to compare the treatment groups thought to be.

5. Conclusion

In this study, the test was conducted for six weeks to examine the effect of the application of Russian current on the muscular performance and activity of the quadriceps femoris muscle based on 20 convalescent patients after having leg fracture, and the following conclusion was obtained. The muscular performance difference by duration depending on the application of the Russian current showed the significant increase in all muscular performances from after four weeks. In addition, the activity of all muscles of the quadriceps femoris muscle by duration showed significant increase from after four weeks. These results showed that the Russian current can be the

effective treatment method for enhancing the muscular strength of the weakened lower limbs muscle due to the problem such as the leg fracture etc.

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