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Effects of the Early Sensorimotor Training on Vastus Medialis Oblique Muscle Activation in Patients after Partial Medial Meniscectomy

Background: Early rehabilitation after partial meniscectomy is important to recover the balance of the vastus medialis oblique and vastus lateralis and prevent pathological problems in the lower extremities and the whole body.
Objective: To compare muscle activations for patients after partial meniscectomy.
Design: Dual-group Pretest-Posttest Design from the Quasi-Experimental Research.
Methods: Twenty participants after partial meniscectomy were recruited and were randomly divided into a Q-setting sensorimotor training group (QSMTG) and Q-setting exercise group (QSEG). Muscle activity of the vastus medialis oblique and vastus lateralis was measured before and after intervention.
Results: In the two groups, the vastus medialis oblique and vastus lateralis activations increased significantly ($P<.05$). The Q-setting sensorimotor training group showed more increases than the Q-setting exercise group, and there were significant differences between the groups ($P<.05$). The activation ratio of the vastus medialis oblique and vastus lateralis had increasingly significant differences in the Q-setting sensorimotor training group ($P<.05$), and there were no significant differences between the groups ($P>.05$).
Conclusion: Q-setting exercise with sensorimotor training was a useful method that improved the balance of vastus medialis oblique (VMO) and vastus lateralis (VL) activity after meniscectomy.

Keywords: *Q-setting exercise; Sensorimotor training; Muscle activations; Vastus medialis oblique; Vastus lateralis; Ratio in VMO and VL*

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INTRODUCTION

The meniscus is important to the normal biomechanical function of the knee joint, as it withstands tension, shear and compressive forces, and its loss is associated with instability and the degeneration of the joint.[1,2] A meniscal injury is a common source of knee joint pain, and approximately 61 in 100,000 meniscal injury patients undergo meniscectomy.[3] A medial meniscus is injured twice as frequently as a lateral meniscus, and generally the injury mechanism of the medial meniscus is associated with the axial rotation, which causes excessive valgus stress in the knee and stress in the medial collateral ligament and posteromedial joint capsule.[4]

Arthroscopic meniscectomy may result in pain, joint effusion, range of motion and muscle atrophy.[5] Middle-aged patients still had muscular and functional deficits four years after the procedure.[6] After meniscectomy, the hamstring's strength recovers quickly, but on the other hand, the quadriceps' strength is markedly decreased immediately, and persists for a long time.[7] Since meniscectomy, there have been many interventions, including modality and isokinetic exercise.[8] Thus, the major goal of early rehabilitation is improving its strength to restore the normal knee joint function.[9,10] The vastus medialis oblique (VMO) and vastus lateralis (VL) work synergistically to stabilize the patella, and the ideal ratio of VMO and VL is 1:1.[11] Among the exercises to strengthen the quadriceps femoris, an isometric contraction of these muscles, called quadriceps setting

exercise, is widely used for early rehabilitation after knee injury.[12] Also, quadriceps' muscular dysfunction might appear due to impairment of the sensorimotor system, as mechanoreceptors in meniscus can be damaged by surgery.[13]

Recently, some studies have suggested the importance of the early application of rehabilitation after meniscectomy.[14] However, there are no studies on the proper exercise protocol in early stage rehabilitation and the effects of Q-setting with sensorimotor training on vastus medialis oblique and vastus lateralis muscle activations. Therefore, the purpose of this study is to compare the effects of Q-setting exercise with and without sensorimotor training on muscle activations in patients after partial meniscectomy. The hypothesis of this study is that the Q-setting exercise with and without sensorimotor training will have differences in muscle activations within group and between groups.

SUBJECTS AND METHODS

Subjects

The subjects of this study were 20 adults who had medial meniscectomy surgery before more than 3 days. The exclusion criteria were as follows: 1) those who had ligaments damage of the knee; 3) those who had previous orthopedic surgery except meniscectomy; 4) those who had inflammatory arthritis; 5) those who had severe pain and fever. All subjects were fully informed about the purpose and methods of this study and signed the study consent form voluntarily. This study was approved by the Bioethics Committee of Daegu University (No: 1040621-201911-HR-042-08).

Outcome Measures

The activations of VMO and VL were measured using EMG (4D-MT, Relive, Gimhae, Korea) to compare the differences of activations.

Interventions

Q-setting exercise

The patient lies down with their knee bent at 15-20° above the pillow and then stretches their knee by pushing the heel (Figure 1). While doing this, compensations, such as hip floating and pelvic rotation, must be prevented. The exercise is maintained for 10 seconds and repeated 30 times for three sets.

Sensorimotor training

The patient sits on the edge of a bed with a height lower than the iliac crest. The affected foot is then placed on the dynamic air cushion while bending the knee, and non-affected side puts on back. The patient's opposite hand grips the Thera-band, located over the head on the opposite side, and pulls toward the affected knee (Figure 2). The exercise is maintained 20 times for three sets. The break time is 30 seconds between sets.

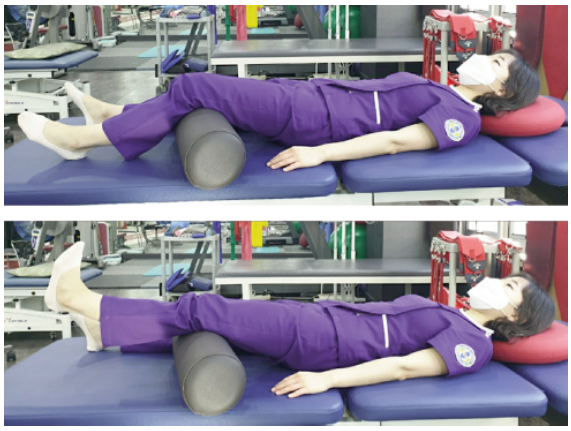

Figure 1. Q-setting exercise.

Figure 2. Sensorimotor training.

Experimental Procedures

Before starting the intervention, the muscle activations of the vastus medialis oblique (VMO) and vastus lateralis (VL) were measured in all subjects using electromyography (EMG), 2EM (4D-MT, Relive, Gimhae, Korea). Subjects were randomly divided into a Q-setting sensorimotor training group (QSMTG, n=10) and Q-setting exercise group (QSEG, n=10).

The intervention was conducted five days a week for two weeks. Muscle activations in all subjects were measured using the same method as the baseline assessment.

The muscle activations of the VMO and VL and the ratio of VMO and VL were measured using electromyography. To minimize the errors during measurements, the electrodes were attached after the subjects cut the hairs on their thighs and cleaned them using alcohol. The two active electrodes were attached on the VMO, 4 cm above and 3 cm from inside the superomedial patellar border at 55° from the long axis of the knee, and the VL, 10–15 cm above and 6–8 cm from the side of the superior border of the patella. The ground electrode was attached at 2–3 cm below the knee on the same side. While the subjects remained pain-free in the sitting position, three repeated measurements were taken every five seconds, three times over the middle three seconds, excluding the first and last. The break time was ten seconds. The method of electromyography was used as a reference voluntary contractions (%RVC), which are standardized based on a specific operation because there are differences when using the maximal voluntary isometric contractions (MVIC) after surgery.

Data and Statistical Analysis

All the data were analyzed with SPSS 23.0 ver for windows (SPSS Inc, Chicago, IL). Means and standard deviation of the general characteristics and variables of the subjects were calculated and Shapiro-wilks test was used for normality. To confirm the differences in the vastus medialis oblique, vastus lateralis and ratio of vastus medialis oblique and vastus lateralis before and after each group exercise, a paired t-test was conducted. To confirm the differences between groups, independent t-test was conducted. The statistical significance level was set to α=.05.

RESULTS

The homogeneity test showed that the two groups were homogeneous because there were no significant differences (P>.05) (Table1).

In the two groups, the vastus medialis oblique and vastus lateralis activations increased significantly (P<.05). The Q-setting sensorimotor training group showed more increases than the Q-setting exercise group, and there were significant differences between the groups (P<.05) (Table2).

The activation ratio of the vastus medialis oblique and vastus lateralis had increasingly significant differences in the Q-setting sensorimotor training group (P<.05), and there were no significant differences between the groups (P>.05) (Table3).

Table 1. Characteristics of subjects.

	QSMTG	QSEG	t	*P*
Gender (M/F)	5/5	5/5		
Age (years)	33.10 ± 5.17	35.70 ± 5.10	−1.13	.27
Height (㎝)	168.90 ± 8.26	165.60 ± 5.83	1.03	.31
Weight (㎏)	65.00 ± 11.40	64.20 ± 4.70	.20	.84

*P<.05, Mean ± Standard deviation
QSMTG: Q-setting sensorimotor training group, QSEG: Q-setting exercise group

Table 2. The comparison of VMO and VL activations (unit: %RVC).

	Group	Pre	Post	Difference value	t	*P*
VMO	QSMTG	21.50 ± 9.28	56.73 ± 12.80	−35.23 ± 6.53	−17.04	00*
	QSEG	19.31 ± 4.82	35.05 ± 10.15	−15.74 ± 7.21	−6.89	.00*
	t	−.66		6.32		
	P	.51		.00*		
VL	QSMTG	27.30 ± 10.67	66.27 ± 15.29	−38.97 ± 7.86	−15.67	.00*
	QSEG	23.45 ± 6.25	44.14 ± 17.74	−20.69 ± 13.98	−4.67	.00*
	t	.98		3.60		
	P	.33		.00*		

*$P < .05$, Mean ± Standard deviation
VMO: Vastus medialis oblique, VL: Vastus lateralis
QSMTG: Q-setting sensorimotor training group, QSEG: Q-setting exercise group

Table 3. The comparison of activations ratio in VMO and VL (unit: ratio).

Group	Pre	Post	Difference value	t	*P*
QSMTG	.79 ± .11	.85 ± .06	−.06 ± .08	−2.56	.03*
QSEG	.83 ± .14	.81 ± .12	.01 ± .13	.45	.65
t	−.81		1.79		
P	.42		.09		

*$P < .05$, Mean ± Standard deviation
VMO: Vastus medialis oblique, VL: Vastus lateralis
QSMTG: Q-setting sensorimotor training group, QSEG: Q-setting exercise group

DISCUSSION

Among the many problems that occur after meniscectomy, the imbalance of quadriceps femoris is most notable, and the vastus medialis oblique is the part weakened most easily. If the balance of the vastus medialis oblique and vastus lateralis is broken, deformities or pathological conditions can occur. This includes not only deformation of the knee joint itself, such as Q-angle, but also other divisions, such as in the foot and hip joint. This study was conducted to compare the changes of VMO and VL activations and their activation ratio.

A study reported that if the meniscus is injured and the injury lasts for a long time, it is easily exposed to the risk of osteoarthritis.[15] After meniscectomy, the ability to extend the knee decreases, and the consequential muscle weakness inhibits reflections of motor fibers.[16] As the imbalance between the vastus medialis oblique and vastus lateralis can lead to patellar maltracking and subluxation, selective strengthening of the vastus medialis oblique is an important goal to increase the medial force acting on the patella.[17] In the VMO and VL activation comparisons, both the Q-setting sensorimotor training and Q-setting exercise groups showed significant increases, but there were more increases in Q-setting sensorimotor training group and significant differences between groups. A study reported that the exercise using an unstable surface improved muscle strength and alignment of the lower extremities[18]. Based on these results, the Q-setting exercise is regarded as a good method to improve VMO and VL activations, and the Q-setting exercises with sensorimotor training are more effective in increasing activations.

A study reported that the ratio in VMO and VL was normalized after the Q-setting exercise was implemented to strengthen the quadriceps femoris.[19] This study also found that while the ratio is within normal range, the VL activation has increased more than VMO activation. It is regarded that although the Q-setting exercise was focused on VMO, the whole muscles of the quadriceps femoris were involved in knee extension.

It is important to ensure a balance VMO and VL to 1:1 since the imbalance of these muscles causes chronic pain and reduces motor performance by repeating functionally incorrect behavior.[20] In the VMO:VL ratio comparison, the Q-setting sensorimotor training group improved significantly, but there were no significant differences between groups. Since this study was conducted for the purpose of early rehabilitation and intervention was conducted for two weeks, it is regarded that there will be significant differences between the groups if the duration is extended.

There were several limitations in the present study. It was difficult to generalize the study results due to the small number of subjects. In addition, the intervention period was short. For the future study, more subjects and more than four weeks of intervention will be applied to determine and compare the effects of the exercises.

CONCLUSION

In conclusion, this study suggests that Q-setting exercise with sensorimotor training can be useful for normalizing the balance of VMO and VL activations after meniscectomy and can prevent possible pathological problems.

REFERENCES

1. Taylor V, Hicks J, Ferguson C, Willey J, Danelson K. Effects of tissue culture on the biomechanical properties of porcine meniscus explants. *Clin Biomech.* 2019;69:120-126.
2. Dias JM, Mazuquin BF, Mostagi FQ, et al. The effectiveness of postoperative physical therapy treatment in patients who have undergone arthroscopic partial meniscectomy: systematic review with meta-analysis. *J Orthop Sports Phys Ther.* 2013;43(8):560-576.
3. Jeong HJ, Lee SH, Ko CS. Meniscectomy. *Knee surgery & related research.* 2012;24(3):129.
4. Neumann DA. *Kinesiology of the Musculoskeletal System: Foundations for Rehabilitation.* 2nd ed. St Louis: Elsevier; 2010:528
5. Koutras G, Letsi M, Papadopoulos P, Gigis I, Pappas E. A randomized trial of isokinetic versus isotonic rehabilitation program after arthroscopic meniscectomy. Int *J Sports Phys Ther.* 2012;7(1):31.
6. Malliou P, Gioftsidou A, Pafis G, et al. Proprioception and functional deficits of partial menisectomized knees. *Eur J Phys Rehabil Med.* 2011;47:465-474.
7. McLeod MM, Gribble P, Pfile KR, Pietrosimone BG. Effects of arthroscopic partial meniscectomy on quadriceps strength: a systematic review. *J sport Rehabil.* 2012;21(3):285-295.
8. Goodwin PC, Morrissey MC. Physical therapy after arthroscopic partial meniscectomy: is it effective? *Exerc Sport Sci Rev.* 2003;31(2):85-90.
9. Imoto AM, Peccin S, Almeida GJ, Saconato H, Atallah AN. Effectiveness of electrical stimulation on rehabilitation after ligament and meniscal injuries: a systematic review. *Sao Paulo Medical Journal.* 2011;129(6):414-423.
10. Jang YS, Kim MK, Kim JS, et al. Effects of the home physical therapy on recovery of muscle strength and gait for discharged patients who underwent total knee replacement. *J Int Acad Phys Ther Res.* 2014;5(2):743-751.
11. Irish SE, Millward AJ, Wride J, Haas BM, Shum GL. The effect of closed-kinetic chain exercises and open-kinetic chain exercise on the muscle activity of vastus medialis oblique and vastus lateralis. *J Strength Cond Res.* 2010;24(5):1256-1262.
12. Park D, Kim J, Lee H. Effectiveness of modified quadriceps Femoris muscle setting exercise for the elderly in early rehabilitation after Total knee arthroplasty. *J Phys Thera Sci.* 2012;24(1):27-30.
13. Ericsson YB, Dahlberg LE, Roos EM. Effects of functional exercise training on performance and muscle strength after meniscectomy: a randomized trial. Scand *J Med Sci Sports.* 2009;19(2):156-165.
14. Ericsson YB, Roos EM, Dahlberg L. Muscle strength, functional performance, and self-reported outcomes four years after arthroscopic partial meniscectomy in middle-aged patients. *Arthritis Rheum.* 2006;55(6):946-952.
15. Neyret P, Donell S, Dejour H. Osteoarthritis of the knee following meniscectomy. *Rheumatology.*

1994;33(3):267-268.
16. Hopkins JT, Ingersoll CD, Krause BA, Edwards JE, Cordova ML. Effect of knee joint effusion on quadriceps and soleus motoneuron pool excitability. *Med Sci Sports Exerc.* 2001;33(1):123-126.
17. Dursun N, Dursun E, Kiliç Z. Electromyographic biofeedback-controlled exercise versus conservative care for patellofemoral pain syndrome. *Arch Phys Med Rehabil.* 2001;82(12):1692-1695.
18. Nam CW, Kim K, Lee HY. The influence of exercise on an unstable surface on the physical function and muscle strength of patients with osteoarthritis of the knee. *J Phys Ther Sci.* 2014;26(10):1609-1612.
19. Laprade J, Culham E, Brouwer B. Comparison of five isometric exercises in the recruitment of the vastus medialis oblique in persons with and without patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 1998;27(3):197-204.
20. Lam PL, Ng GY. Activation of the quadriceps muscle during semisquatting with different hip and knee positions in patients with anterior knee pain. *Am J Phys Med Rehabil.* 2001;80(11):804-808.